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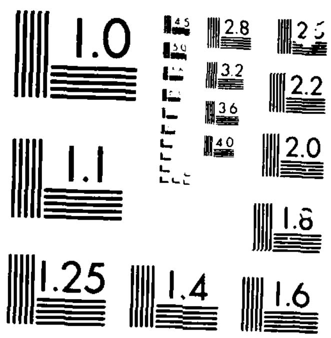

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AN ANALYSIS OF PLANNED ARMY GROUND MOBILE FORCES (GMF) SATELLITE USE IN SUPPORT OF MOBILE SUBSCRIBER EQUIPMENT

FINAL REPORT 178
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CENTER FOR COMMAND AND CONTROL, AND COMMUNICATIONS SYSTEMS (C^4S)

" EXCELLENCE IN C^3 SYSTEMS FOR NATIONAL DEFENSE"

ANALYSIS OF PLANNED ARMY GROUND MOBILE FORCES (GMF) SATELLITE USE IN SUPPORT OF MOBILE SUBSCRIBER EQUIPMENT (MSE)

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CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Today's Army is faced with the challenge to fight and win against hostile enemy forces in land combat operations that may occur in a number of widely varying theaters of operation ranging from the relatively compact European theater to the widespread Southwest Asian theater. The current Army AirLand Battle doctrine requires that command, control, and communications (C^3) of Army forces be capable of supporting commanders in the conduct of military operations in the deep, close-in, and rear areas of battle in these diverse theaters.

To meet these requirements, the Army is in the process of acquiring various tactical communications systems. Among these are the Army Ground Mobile Forces super high frequency (SHF) satellite communications system, which provides multichannel tactical satellite service to Army units from brigade to theater, and the Mobile Subscriber Equipment (MSE) system, which provides multichannel switched service to echelons below corps using primarily terrestrial multichannel transmission systems.

A previous study ~~(Reference 1)~~ which analyzed Army GMF(SHF) satellite communications (SATCOM) deployment alternatives, concluded that the operational and system relationship between GMF (SHF) SATCOM and other Army communications systems, particularly MSE, had not been fully defined, and a separate study to fully address this relationship was recommended. It is the purpose of this report to document that relationship and to develop the basis for continuing the study to determine where and how military satellite communications (MILSATCOM) can best be used to enhance the Army MSE system.

1.2 APPROACH

The task of determining where and how MILSATCOM can best be used to enhance the Army MSE architecture has been divided into three subtasks as shown in Figure 1-1. The first subtask, and the subject of this report, focuses on currently documented operational concepts and known capabilities of both MSE and MILSATCOM, particularly the Army GMF(SHF) SATCOM. Once this baseline is established, Subtask 2 will develop realistic operational scenarios for employment of MSE, including projected traffic requirements. Subtask 3 will develop MILSATCOM augmentations/enhancements to these MSE scenarios and will evaluate the system performance using simulation tools where appropriate. Based on an analysis of the performance, enhancements to MSE and/or MILSATCOM systems will be recommended.

1.3 ORGANIZATION OF REPORT

This report is organized into six chapters including this introduction. Chapter 2 provides an overview of the Army tactical communications architecture. Chapter 3 contains a relatively detailed technical and operational description of the Army GMF(SHF) SATCOM capabilities, and Chapter 4 contains a similar treatment of MSE. Chapter 5 summarizes current Army plans to use GMF(SHF) SATCOM in support of MSE and analyzes the impact of that planned utilization. Chapter 6 contains the overall conclusions of this phase of the study and recommends a course of action to complete the study.

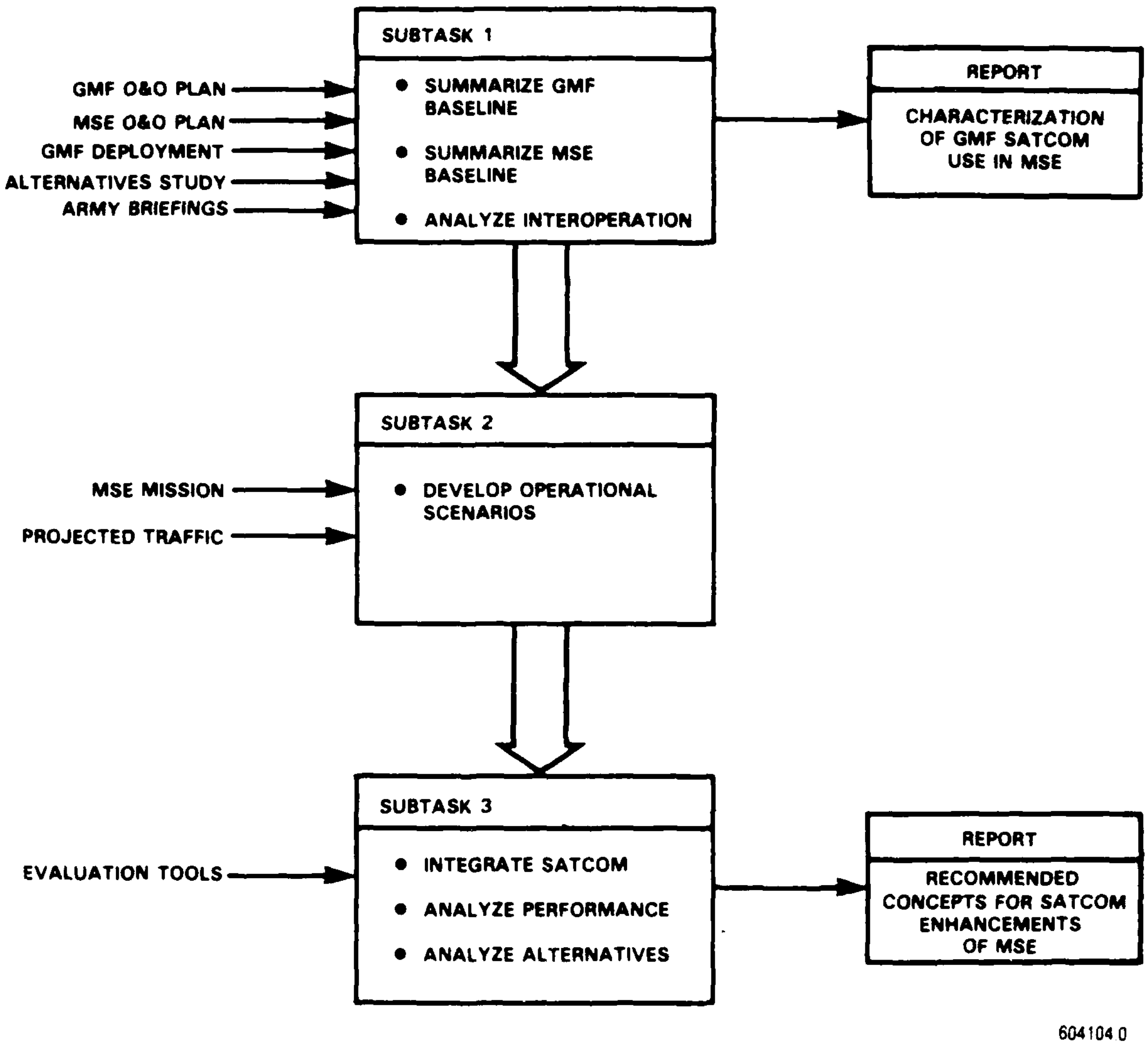


Figure 1-1. Study Approach

CHAPTER 2

ARMY TACTICAL COMMAND, CONTROL COMMUNICATIONS (C^3) ARCHITECTURE

To determine where and how Ground Mobile Forces (GMF) super high frequency (SHF) satellite communications (SATCOM) can best be used to enhance the Army mobile subscriber equipment (MSE) architecture, it is necessary to understand the Army's command, control, and communications (C^3) architecture and the automation and communications systems that are being fielded to support the military operational requirements in various theaters.

The Army's mission is to carry out land combat operations that may occur in a number of widely varying theaters of operations. Battles may occur against stylized Soviet-type forces in Europe, against well equipped adversary forces in Korea, or against Soviet surrogate forces in contingency theaters such as Southwest Asia. The *AirLand* Battle doctrine requires that tactical C^3 be capable of supporting Army forces in the conduct of simultaneous battles in the deep, close-in, and rear areas. The purpose of the deep battle is to delay, disrupt, or destroy the enemy's uncommitted follow-on forces and to isolate his committed forces so that they can be destroyed. The close-in battle is fought to defeat committed forces, to maintain control at the forward line of own troops (FLOT), and to shape the battle to create opportunities for offensive action. The rear battle is fought to preserve freedom of action for uncommitted, friendly forces and support forces in the rear area.

In practice, these three battles may occur simultaneously and be indistinguishable on the battlefield. The tactical C^3 system must permit Army forces a maximum degree of flexibility to coordinate and unify their efforts. It must provide a rapid and reliable, standard means for command and control in all theaters. It must be able to rapidly disseminate both the commanders' orders and essential battlefield information. Positive control of all forces must be provided, but the flexibility of subordinate commanders to carry out their missions in a dynamic battlefield environment must not be hindered. In effect, all components of the Army's C^3 system must be fully integrated and mutually supporting.

The tactical C^3 architecture to provide these capabilities is depicted in Figure 2-1. This C^3 architecture consists of automated systems and a set of communications systems to support operational requirements in five functional areas at operational facilities/command posts from battalion through corps. The five functional areas in the architecture are maneuver control (MVR), intelligence and electronic warfare (IEW), fire support, air defense artillery (ADA), and combat service support (CSS). All functional areas require tactical data systems and communications support at the designated operational facilities throughout the corps area. These operational facilities and their supporting data systems are provided communications by three types of systems: single-channel radio, single/multichannel switched, and data distribution. In the Army's tactical architecture, these are called the combat net radio (CNR) system, the area common user (ACU) system, and the data distribution system (DDS).

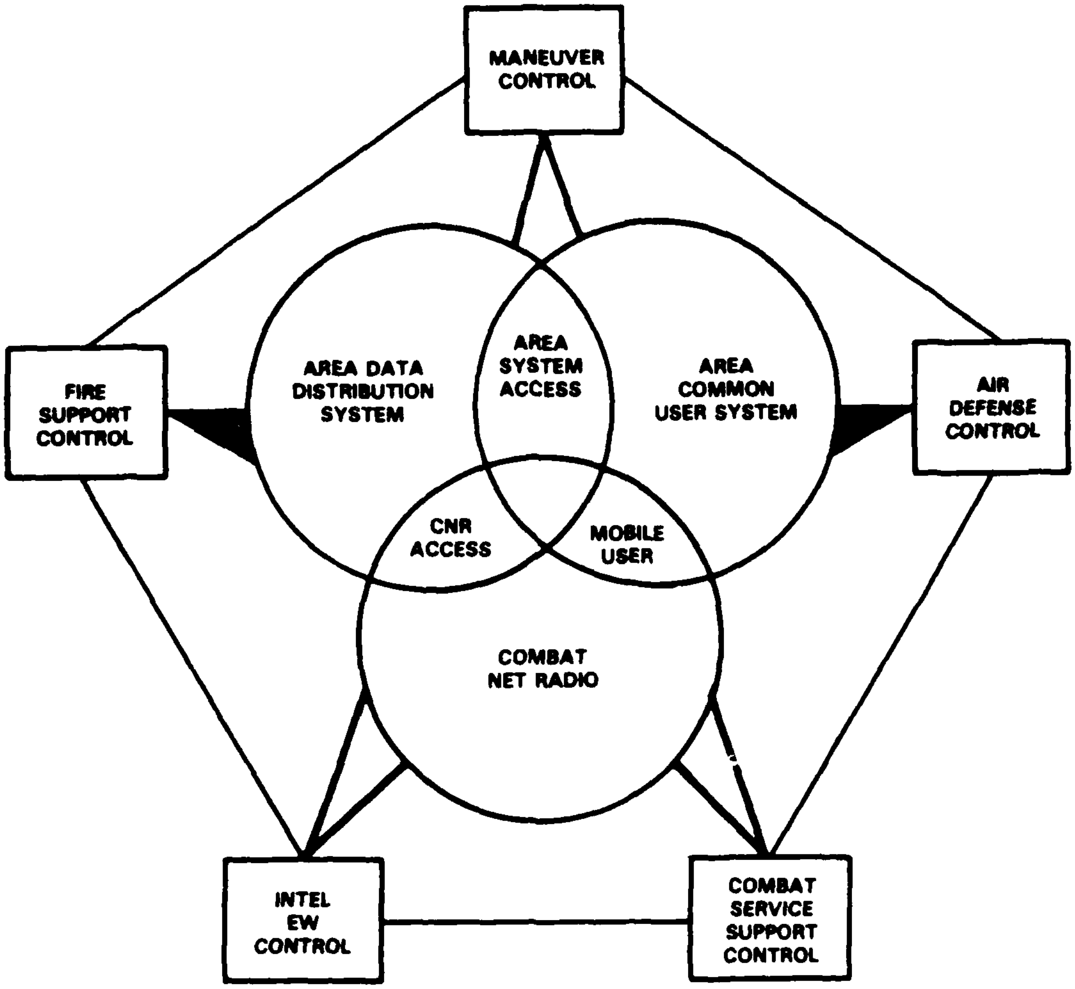


Figure 2-1. Army C3 Architecture

This study assumes that the single-channel ground and airborne radio system (SINCGARS) is the CNR, which is a single-channel, VHF-FM radio providing secure voice/data transmissions at 16 kbps. Although other high-frequency (HF) and UHF radios are used by the Army for air defense and air-ground operations, SINCGARS provides the bulk of the combat net radio capabilities and also has a specified ACU interface requirement. The position location reporting system (PLRS)/ joint tactical information distribution system (JTIDS) hybrid (PJH) has been designated by the Army as its DDS. This system will provide terminal-to-terminal data transfer, using formatted messages at rates up to several hundred kilobits. The ACU is a composite set of single/multichannel access systems that use both terrestrial (e.g., line-of-sight (LOS) microwave) and satellite (e.g., Defense Satellite Communications System (DSCS) III) transmission systems. The ACU consists of user terminals and switching, transmission, and control equipment, which are components of the joint tactical communications (TRI-TAC) program and the MSE system. The ACU also includes GMF SATCOM ground, control, and satellite segments.

In the near term, the SATCOM support will be provided by the SHF system (e.g., AN/TSC-85A/93A, MSC-114, DSCS II/III). In the mid and far term, the extremely high frequency (EHF) system [i.e., the Milstar Single Channel Objective Tactical Terminal (SCOTT)] will support C^2 requirements from selected brigade elements at division through theater levels. It will provide up to four voice equivalent channels of antijam secure communications. Currently the Army Signal School indicates that SCOTT is a part of the ACU.

An overall generic network depiction of the interrelationships of the three major communications systems is shown in Figure 2-2. At the lowest echelons (e.g., company and battalion), the SINCGARS radio will provide the majority of the communications for the combat forces. Manpack, vehicular, and airborne (e.g., helicopter) radios will be used for command and control of tactical ground operations. However, these radios will interface with the ACU at specific nodes to provide voice/data access to higher headquarters. The PJH system will provide two key capabilities. At the lowest levels, air defense units (e.g., STINGER, Vulcan/Chaparall teams) will receive near-real-time data on enemy aircraft penetrating into friendly airspace. This will allow their weapons' system to rapidly engage these hostile aircraft. PJH will also provide a position, location information, and control capability. More importantly, PJH will provide the primary computer-to-computer data link at battalion, brigade, division, and corps levels for the five functional C^2 segments--air defense, fire support, intelligence/electronic warfare, maneuver control, and combat service support. The PJH system may also interface with the ACU primarily at brigade level and above; however, at present this requirement has not been validated and MSE has no explicit provisions to provide the interface.

In the corps and division areas, the MSE system will provide the area grid primarily for voice communications, although data and facsimile capabilities will also be provided to static and selected mobile subscribers. This grid network is shown in the lower left portion of Figure 2-2. Also depicted are the interconnections to the TRI-TAC area system for echelons above corps and to both the SINCGARS and PJH systems. Other important tactical communications capabilities shown in Figure 2-2 are the GMF(SHF) and (EHF) systems. The

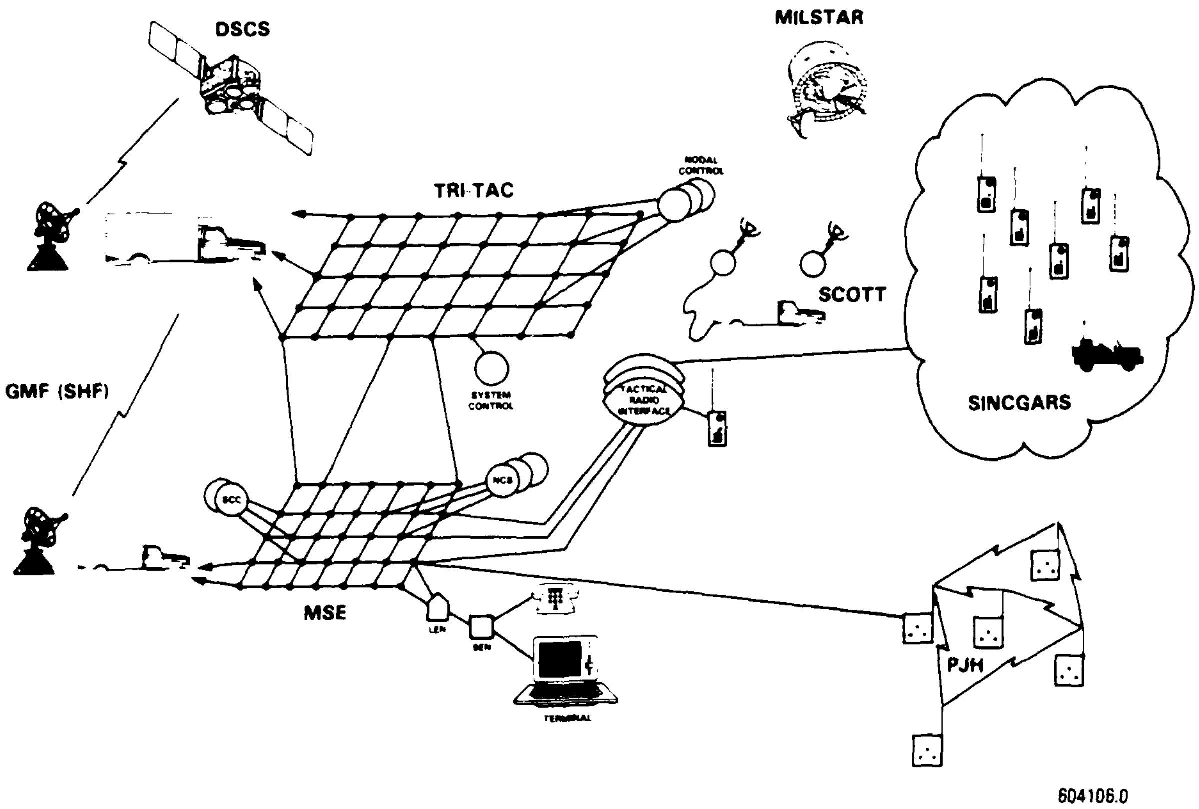
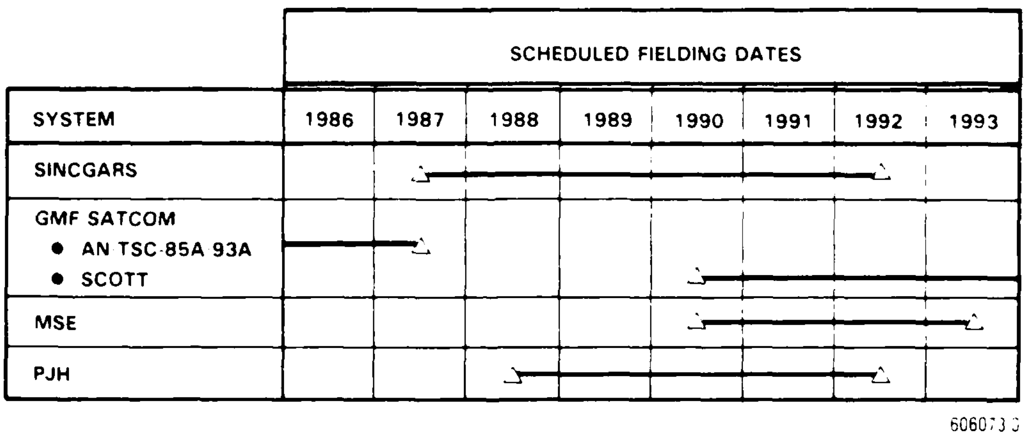


Figure 2-2. Army Tactical Communications Network

SHF system will be deployed to division, corps, and echelons above corps. As mentioned previously, SCOTT is an EHF system to support C^2 requirements from selected brigade elements at division through theater levels.

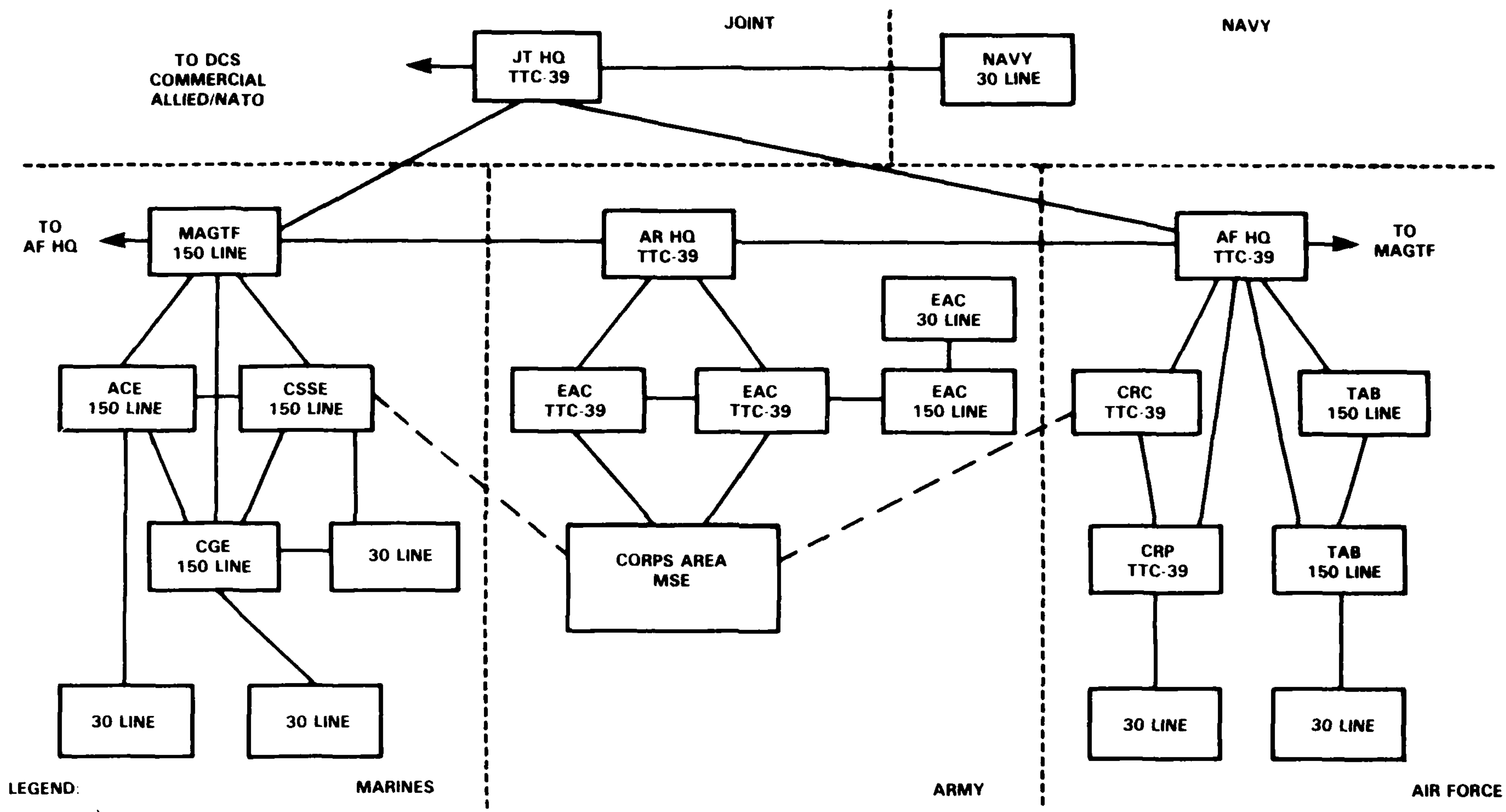
In effect, the Army tactical communications architecture is a "network of networks," with corps and division subscribers served by area voice/data networks (MSE, PJH), a single-channel radio network (SINCGARS), and two satellite networks--GMF(SHF) and (EHF) SATCOM. Table 2-1 indicates the planned fielding dates for these systems.

Table 2-1. Army Communications Systems Fielding Schedule



The relationship of the Army's ACU to the total Department of Defense (DoD) Tactical Switched Architecture is depicted in Figure 2-3. In the DoD architecture, a generic joint task force is composed of component forces from all four Services. Each of the Services will employ compatible TRI-TAC equipment, primarily the AN/TTC-39 circuit switch and its derivatives (e.g., unit level 30 and 150 line switches) at organizational levels from battalion to component (e.g., MAGTF, AR HQ, AF HQ, Navy Task Force). These organizations will be interconnected within each Service's force structure as well as at joint interface points. Interoperability is ensured between all Services where TRI-TAC equipment is used. Interoperability is also required between the MSE system and the TRI-TAC AN/TTC-39 equipment in the Army. With this connectivity, indirect interoperability between MSE and the other Services is achieved using the TRI-TAC system as the common interface. Potential connectivity between the Army's corps/division MSE system and the Air Force and Marine TRI-TAC equipment may be a requirement, depending on the actual scenario.

A primary purpose of this study is to determine the MSE-GMF(SHF) operational and technical requirements and capabilities and specifically determine how GMF(SHF) SATCOM can enhance MSE capabilities. The total context of the DoD's Tactical Switch architecture, including the Services' implementation plans, must be considered for exploitation of GMF(SHF) SATCOM as a potential means to enhance joint interoperability.



LEGEND:

30 LINE, 150 LINE } UNIT LEVEL SWITCH CAPACITY

ACE · AIR COMBAT ELEMENT
AF HQ · AIR FORCE COMPONENT HEADQUARTERS
AR HQ · ARMY COMPONENT HEADQUARTERS
CGE · COMBAT GROUND ELEMENT
CRC · CONTROL AND REPORTING CENTER
CRP · CONTROL AND REPORTING POST
CSSE · COMBAT SERVICE SUPPORT ELEMENT
EAC · ECHELON ABOVE CORPS
JT HQ · JOINT HEADQUARTERS
TAB · TACTICAL AIR BASE
TTC-39 · TRI TAC CIRCUIT SWITCH

Figure 2-3. DoD Tactical Switched Architecture

CHAPTER 3

DESCRIPTION OF ARMY GROUND MOBILE FORCES SHF SATELLITE COMMUNICATIONS

This chapter provides a description of the Army Ground Mobile Forces (GMF) super high frequency (SHF) multichannel satellite communications (SATCOM) system from both a technical and an operational perspective. After a brief overview of the overall GMF SHF SATCOM architecture, a technical description of both the space segment and the terminal (ground) segment is provided. This is followed by an operational description of Army plans for employment of this system in the theaters also scheduled to receive mobile subscriber equipment (MSE).

3.1 GMF SHF SATCOM ARCHITECTURE

Three basic configurations of GMF SHF ground-based terminals can access the Defense Satellite Communication System (DSCS) satellite constellation. The three configurations are designated as nodal (or hub) terminals, link (or spoke) terminals, and control terminals. As shown in Table 3-1, there are two versions of both the nodal and link terminals to meet the unique requirements of the Services. Prior to the acquisition of MSE it was expected that the terminals would be deployed in networks ranging in complexity from a small independent set of terminals supporting a special mission to a large complex network supporting joint task force missions. This is shown in Figure 3-1.

Table 3-1. GMF SHF SATCOM Terminal Configurations

Service	Node or Hub Terminal	Link or Spoke Terminal	Control Terminal
Army/Marines	AN/TSC-85A	AN/TSC-93A	MSQ-114
Air Force	AN/TSC-100A	AN/TSC-94A	--

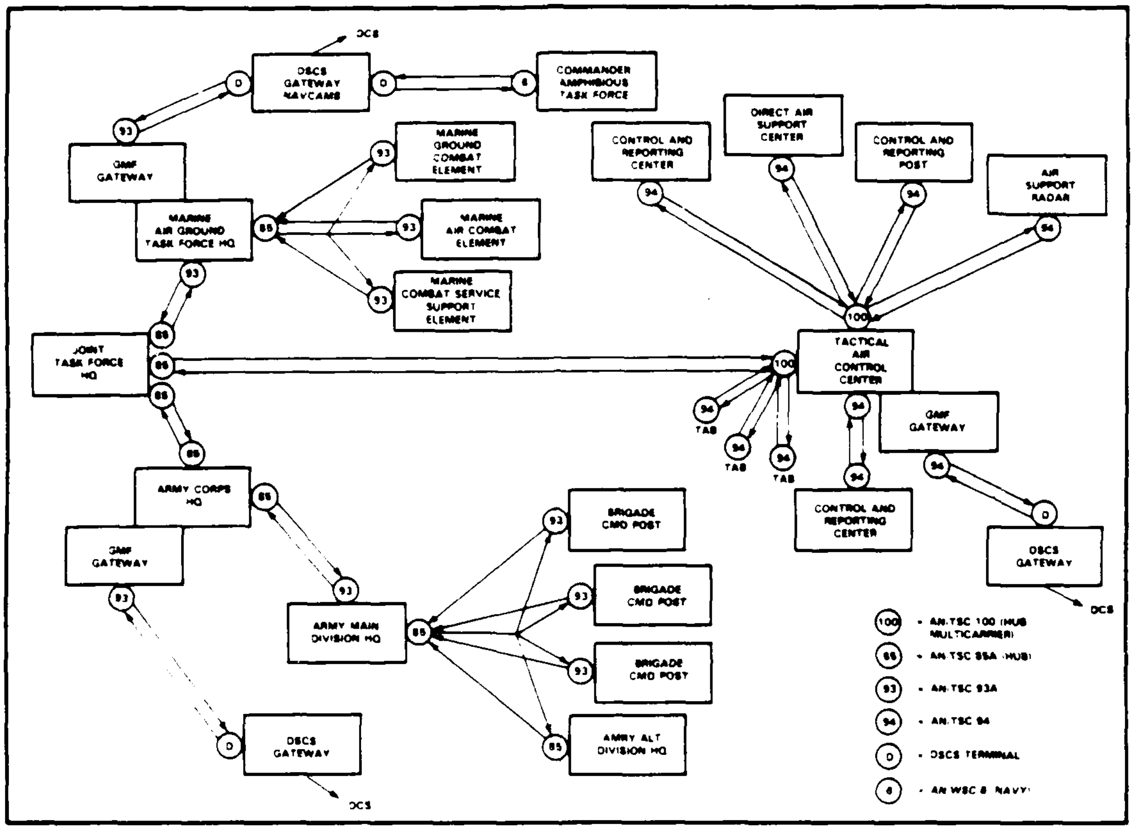


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Figure 3-1. Example of Joint Service GMF Deployment

As can be seen from Figure 3-1, the nodal terminals (TSC-85A and TSC-100A) would normally be employed at headquarters locations and connectivity established to several link terminals located at subordinate units, thus forming a hub-spoke configuration. When MSE becomes a major part of the ACU at corps/division, the AN/TSC-85A/93A can be deployed in variants of the hub-spoke or mesh configurations.

The link terminals can transmit and receive only a single carrier and, therefore, can only be used as a spoke or in a point-to-point mode, as shown between Army Corps Headquarters and Army Main Division Headquarters.

3.1.1 Space Segment

The communications requirements of the Army GMF are supported on a worldwide basis by the satellite assets of the Defense Satellite Communications System (DSCS) operating in the SHF portion of the frequency spectrum.

At the time MSE is fully deployed, it is expected that the DSCS operational space segment will consist of a five-satellite DSCS III constellation. The orbital locations will be the Eastern Pacific (EP) at 135°W, Atlantic 2 (ATL2) at 52.5°W, Atlantic 1 (ATL1) at 12°W, Indian Ocean (IO) at 60°E, and Western Pacific (WP) at 175°E.

Figure 3-2 illustrates the full field-of-view for this five-satellite DSCS III space segment. The shadings in the figure indicate the number of DSCS III satellites visible to each point on the Earth. The shading also indicates the number of potential GMF coverage areas that can be supported. For example, up to three GMF deployments can be accommodated in Europe, but only two can be supported in Southwest Asia and Korea. These are maximum coverages and assume that there are

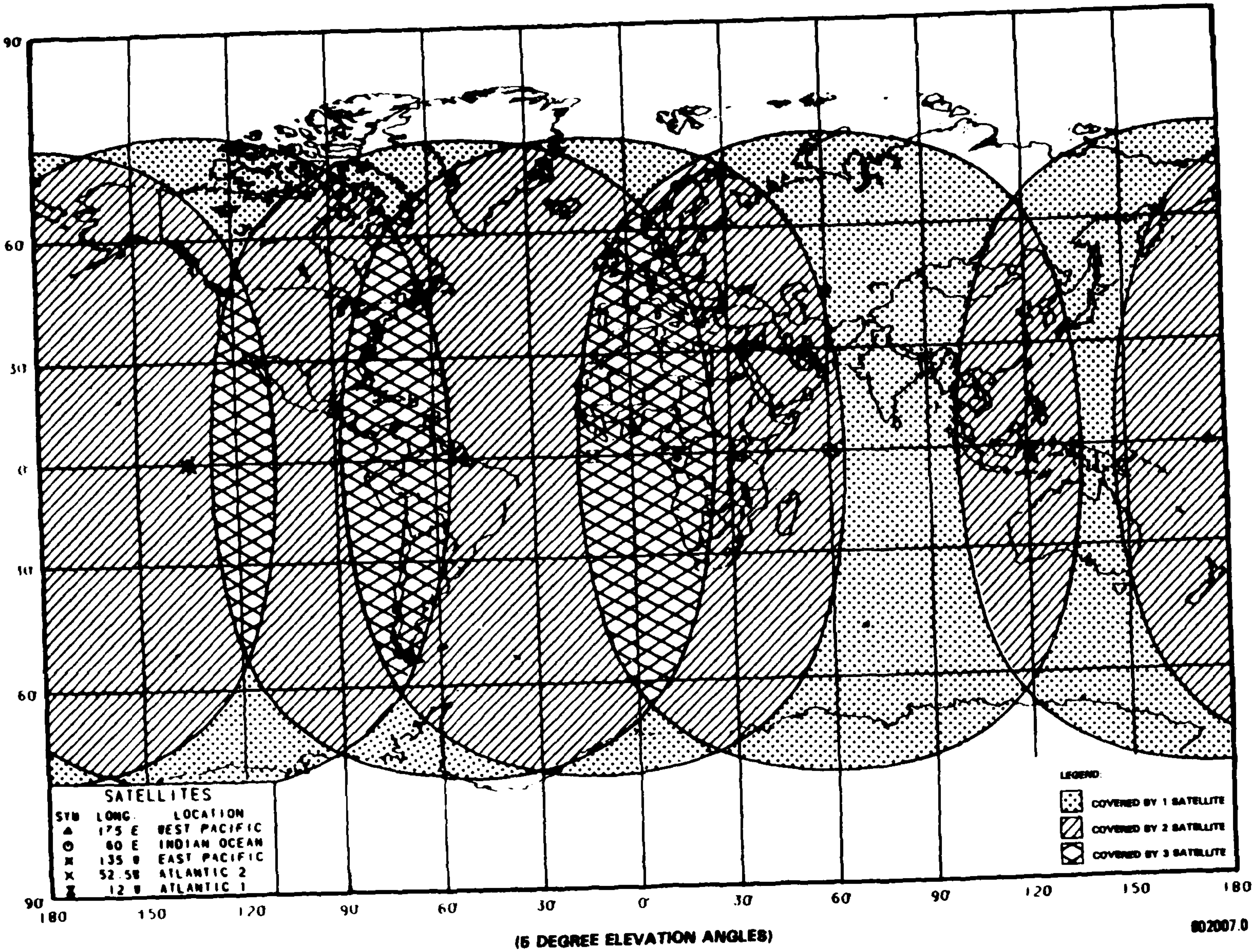

Figure 3-2 Earth Coverage of Five Satellite DSCS III Constellation

no other GMF deployments in the areas covered by the satellites. For example, a Southwest Asian deployment would reduce to two the number of European deployments. A worldwide maximum of five GMF deployments will be possible.

The GMF community will be serviced on channel 2 of DSCS III satellites, which has a downlink effective isotropic radiated power (EIRP) of 44 dBW (at the edge of a 3-dB antenna contour with a 3-dB backoff of the satellite downlink amplifier). Channel 2 has 60 MHz of bandwidth in current models and is equipped with a steerable downlink gimballed dish antenna (GDA) that provides an elliptical coverage area with a minor axis between 700 and 1000 miles at the half-power transponder output. Starting with satellite DSCS III B8, the bandwidth of channel 2 will be increased to 75 MHz. The channel 2 uplink is either through the 61-element multiple beam receive (MBR) antenna or an earth coverage horn antenna. GMF typically uses the upink MBR, which provides spatial nulling of jammers. Shared use of the uplink antenna with other transponders and users mandates centralized network resource allocation and satellite configuration management by Defense Communications Agency (DCA) with the cooperation of the GMF manager. (Chapter 5 more fully discusses the issues of resource allocation and control of GMF capacity.)

3.1.2 Satellite Capacity

The capacity of the channel 2 transponder in terms of total throughput in bits per second is a function of several variables related to the actual deployment of ground terminals. These variables include terminal size, terminal dispersement, and satellite coverage pattern. Reference 2 developed and analyzed several different scenarios that demonstrate the available capacity for individual satellites.

Table 3-2 summarizes the results for those theaters that are the subject of this study. The European scenario typifies a generic GMF scenario with user locations highly clustered. It consists of 49 terminals transmitting a total of 67 frequency-division multiple-access (FDMA) carriers and using all available channel 2 power and bandwidth. The resulting throughput is 34.7 Mbps. This equates to 2,079 16-kbps channels and provides an additional 24-kbps overhead channel for each link for control and synchronization.

Table 3-2. GMF Scenario Summary

Scenario Name	Satellite Region	Baseline Capacity (Mbps)	Channel 2 Resources (Percent)	# of FDMA Carriers/ Terminals	No. of 16-kbps Channels
Europe	ATL	34.7	100	67/49	2070
Korea	WPAC	26.8	98	45/21	1605
SW Asia	IO	12.4	96	40/40	720

The Korean scenario consisted of 21 terminals transmitting 45 FDMA carriers capable of 26.8 Mbps total throughput through channel 2. This equates to 1605 16-kbps channels, again allowing for the 24-kbps overhead per link. The reason for the lower capacity is that the Korean scenario has a larger percentage of 8-ft. terminals.

The Southwest Asian scenario consists of 40 terminals transmitting 40 FDMA carriers. Using all 8-ft. terminals, the supportable throughput is 12.4 Mbps or 720 16-kbps channels.

The above results were obtained using the DSCS Network Planning System (DNPS) program available at the Defense

Communications Engineering Center and are based on several assumptions documented in Reference 2. These throughput capacities are presented here to indicate the relative capacity available on each satellite for all users of channel 2 and to provide a basis for comparison later in the study. The scenarios do not reflect any consideration of MSE requirements, nor do they consider double or triple satellite coverage in any area. Typically the entire capacity of channel 2 is available for allocation within the GMF community; however, there are other potential users of channel 2 who may be allocated part of the capacity.

3.1.3 Terminal Segment

Three basic types of Army GMF terminals operate through DSCS satellites: the AN/TSC-85A hub terminals, the AN/TSC-93A spoke terminals, and the AN/MSQ-114 control terminals used for GMF network control.

The AN/TSC-85A serves as a nodal terminal providing full-duplex multichannel links to up to four other destinations using the same satellite. It can operate as the hub of a hub-spoke configuration or as one node of a mesh configuration. The AN/TSC-93A is used as a spoke or point-to-point terminal providing a single duplex multichannel link. The two terminal configurations have a large degree of equipment similarity. The main difference is the presence of multiple sets of electronic equipment at the AN/TSC-85A required for providing a nodal configuration.

Figure 3-3 shows the hub-spoke configuration typically employed with these terminals and indicates a typical frequency plan allowing each terminal to trasmit on a separate frequency. Figure 3-4 shows the mesh configuration using all AN/TSC-85As.

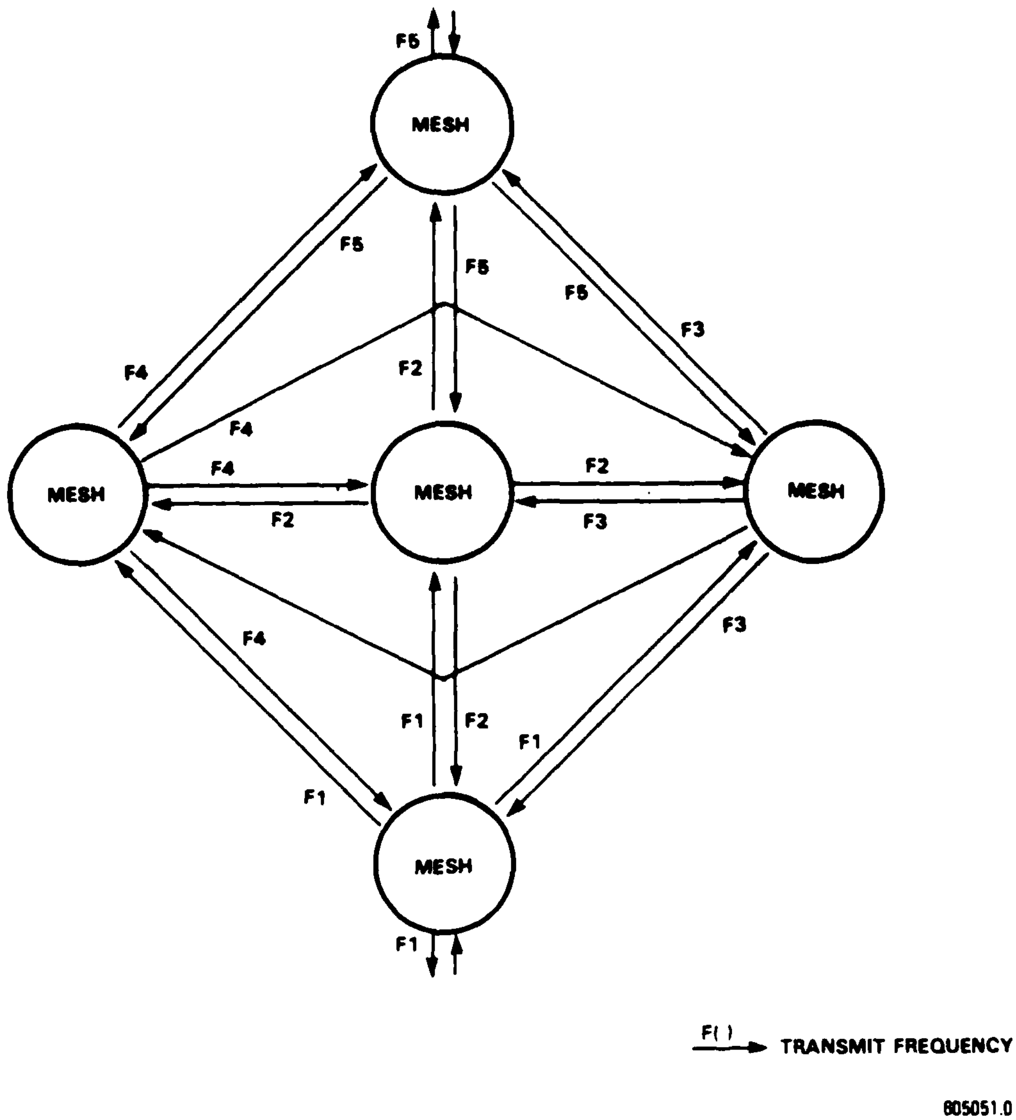

Figure 3-4 Mesh Terminal Configuration

3.1.3.1 AN/TSC-85A Terminal

The user input and multiplex structure of the AN/TSC-85A are shown in Figure 3-5. The AN/TSC-85A can transmit up to 48 individual channels (at 48 kbps per channel) using internal TD-660 multiplexer equipment. An additional 48 channels can be added using external multiplexer equipment. TRI-TAC-type digital trunk groups (DTGs) can also be transmitted using external multiplexer equipment. When operating in conjunction with the self-contained multiplexer equipment, up to four groups each at up to 576 kbps can be accommodated. When operating exclusively with externally multiplexed TRI-TAC-type DTGs, each of the four groups can be up to 1152 kbps.

The AN/TSC-85A can receive up to four SHF carriers simultaneously, demodulating the carriers and supplying the resulting digital signal either to self-contained or external multiplexer equipment. In the case of TRI-TAC-type digital signals, external multiplexer equipment is used.

The normal interface for the TRI-TAC-type signals is via the group modem (MD 1026), which is a member of the TRI-TAC digital group multiplexer family of equipment. The MD 1026 modem technical specifications are given in Table 3-3.

Two modifications to this terminal are planned. The first is the replacement of the TD-660 multiplexers with TD-1389 low-rate multiplexers (LRM) currently used by the Air Force in its terminals. The LRM is an adaptive time division multiplexer and will provide for direct interoperation between Army and Air Force terminals.

The second modification is the addition of an antijam/ control modem (AJ/CM) which provides an analog voice channel

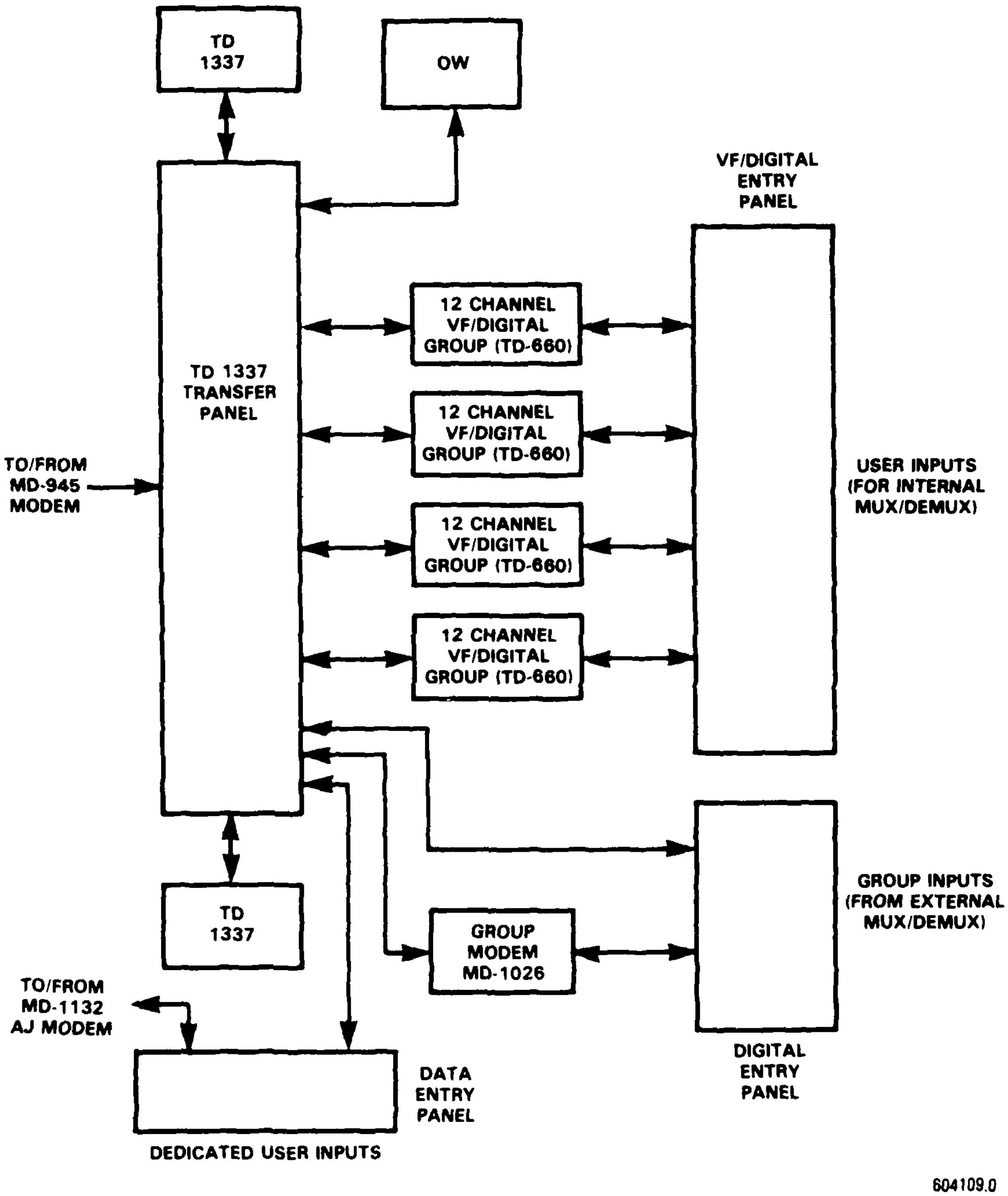

Figure 3-5. AN/TSC-85A Baseband Equipment Block Diagram

Table 3-3. MD 1026 Group Modem Technical Specifications

Modem Characteristic	Specification
No. of Groups	Up to 6
Bit Rates	
Cond. Diphase	128, 256, 512, 1024 15.36, 2048, 4096 kbps 72, 144, 288, 576, 1152, 2304, 4608 kbps
Dipulse	288, 576, 1152, 2304 kbps
Bipolar	1536.2 kbps
Equipment Side Interface	
Signals	Nonreturn to zero (NRZ) data plus square wave timing
Cable	RG-108 (100 ft.)
Cable Side Interface	
Cable	CX-11230 coaxial
Maximum Distance	Cond. diphase 3.2 km Dipulse 1.6 km Bipolar 0.8 km
Orderwires (per group)	
Cond. Diphase	2 kbps and 16 (2.0 mi) or 1 analog (1.0 mi)
Dipulse & Bipolar	1 analog (0.5 mi)

and a data channel at rates of 75 bps, 2.4 kbps, 16 kbps, or 32 kbps. It uses a spread spectrum code-division multiple-access (CDMA) technique and can operate simultaneously with the FDMA modems. Neither of these modifications has a direct effect on the interfacing of TRI-TAC-type DTGs to the terminal.

3.1.3.2 AN/TSC-93A Terminal

The AN/TSC-93A can transmit and receive up to 24 channels (48 kbps per channel) of voice and data in 6-channel increments using 24 channels of self-contained multiplex equipment. It uses the same data buffer, communications security (COMSEC), and multiplexer as the AN/TSC-85A. The VF/high rate digital

entry panel accepts individual analog voice frequency or high-rate digital (16/32 kbps) signals.

The general signal flow and processing is similar to that in the AN/TSC-85A except that a redundant high-power amplifier (HPA) and tactical satellite signal processor (TSSP) are not provided, and the number of up- and downconverters and modems is reduced to support one uplink and one downlink. Also, there is no provision or requirement to receive the network control terminal (NCT) downlink. A partial block diagram of the AN/TSC-93A is provided in Figure 3-6.

3.1.3.3 AN/MSQ-114

The GMF Operational Center (GMFOC) exercises control authority over the limited bandwidth and the share of transponder EIRP assigned to the GMF operation.

The AN/MSQ-114 is the NCT used by the GMFOC to monitor and control GMF theater/area utilization of DSCS resources. It is a self-contained mobile control center capable of monitoring and controlling, by orderwire communications, up to 100 communications terminals.

3.2 GMF SHF SATCOM CONTROL

The Army was assigned the responsibility for operation of the GMF control system in 1978. Developments of this system had until recently assumed that the GMF would operate independently of other DSCS users and that satellite power and bandwidth would be dedicated to it. Under this situation, the Army would coordinate all requests for GMF links, including those by the other Services. However, increased requirements for DSCS access by a number of high-priority users has caused

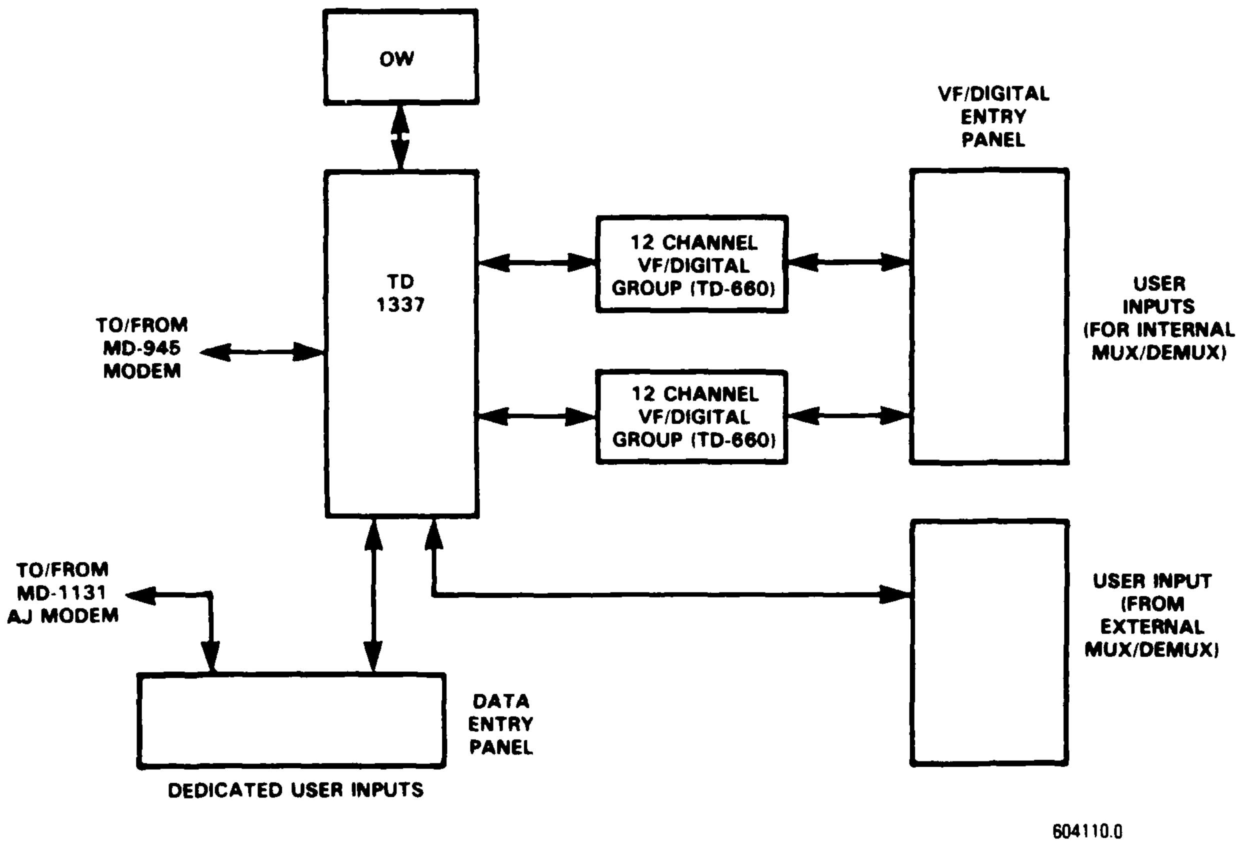

Figure 3-6. AN/TSC-93A Baseband Equipment Block Diagram

concern over the amount of satellite power and bandwidth that will be allocated to the GMF in particular scenarios. Although GMF satellite communications terminals make up the majority of users, other users--such as the White House Communications Agency (WHCA), Joint Chiefs of Staff (JCS), special applications terminal, and the diplomatic telecommunications system--also require access to the DSCS high-gain spot beam transponders. Thus, overall access and allocations are tightly controlled and directed by the JCS.

GMF network control and management in the this environment of changing user priorities and satellite transponder availability is in a state of evolutionary change. DCA circular 800-55 (draft) has proposed that DSCS controllers and GMF controllers be aligned in a hierarchy that would ensure efficient management of the entire network. As yet, the Army has not agreed to implement the DCA proposals. Currently the Army has indicated that it will exercise its assigned responsibility to control the GMF ground segment using the MSQ-114, a self-contained facility to directly support the theater commanders in the technical management of the GMF subnetworks. The GMF control mission is to (1) develop and disseminate the technical parameters and network technical settings required for accessing the satellite and (2) provide efficient utilization of the GMF-allocated satellite resource to maximize the tactical communications capability of the forces under benign and stressed operating conditions.

3.3 CURRENT PLANNED MISSIONS AND SYSTEM CONFIGURATIONS

The Army plans to deploy the GMF(SHF) AN/TSC-85A/93A satellite terminals to provide multimission command and control to forces in Europe, Southwest Asia, Korea, Panama, and Alaska. Special operations forces are also designated to

receive these terminals. This study focuses only on the European, Southwest Asian, and Korean theaters, where the MSE system is also scheduled to be deployed to support Army forces. The following paragraphs summarize the Army's current plans to use the AN/TSC-85A/93A terminals in each of the theaters. It should be noted that in Korea and Southwest Asia, the Army has not altered its planned allocation of GMF SHF SATCOM terminals even though MSE is also being fielded there. In Europe, the Army has reduced the originally planned allocation of terminals by 50 (10 division sets) because MSE will be used to satisfy most of the division ACU requirements.

The normal configuration of AN/TSC-85A and -93A terminals is a hub-and-spoke relationship with the -85A terminal as a hub with up to four -93A terminals interconnected to it as spokes. The -85A hub would allow interconnection to other -85As, -93As, or a gateway terminal. Gateway terminals are necessary to interoperate with users in other channels (other than GMF-assigned channel 2) or users in geographic areas outside a DSCS satellite field of coverage.

3.3.1 Europe

In Europe, the Army plans to use the AN/TSC-85A/93A terminals at corps and at echelons above corps (EAC). The terminal allocations are shown in Table 3-4. At the EAC level, it is likely that the terminals will be configured into hub-and-spoke networks. A detailed description and analysis of the EAC configurations is found in Reference 2.

Table 3-4. Army GMF SHF SATCOM Terminal Allocations for the European Theater

Echelon	Number of Terminals TSC-85A	TSC-93A
Corp (4)	8	16
EAC	7	11
TOTAL	15	27

The Army has allocated each corps two AN/TSC-85A and four AN/TSC-93A terminals to be used on a mission-by-mission basis. Potential missions include support of deep battle forces; restoration of critical links of the corps/division area communications systems; point-to-point command and control (C^2) connectivity between corps and divisions under jamming conditions; special operations and intelligence missions; and support to selected forces assigned missions in or outside of the corps area of operations.

The Army has no current plans to deploy AN/TSC-85A/93A terminals at the division level or below in Europe. Army plans call for only 6/12 channel links (rather than the 48 channels possible) to be used at all levels to reduce satellite power and bandwidth requirements. In the near term, the Army will employ 48 kbps per voice channel multiplex (TD-660s), while in the mid term (1988) it will acquire the LRMs (TD-1389) for use with the terminals. The LRM, which digitizes voice at 16 kbps as well as providing efficient multiplexing of other data signals, not only reduces satellite bandwidth requirements but also provides interoperability with Air Force GMF terminals that are already equiped with LRMs.

Current Army planning documents indicate that the GMF(SHF) terminals will be fully deployed in Europe by 1987. This is approximately 3 years before MSE is scheduled for deployment there.

3.3.2 Southwest Asia

The Army will employ the AN/TSC-85A/93A terminals at echelons of brigade through theater and to CONUS through the Defense Communications System (DCS) gateways. Specifically, Third Army, XVIII Airborne Corps and the 7th, 24th, 82nd, and 101st divisions will be allocated terminals as shown in Table 3-5. The Army currently indicates (Reference 3) that these terminals would be used in hub-spoke configurations. No particular mention of any change to this concept resulting from the deployment of MSE is included. However, it is anticipated that the GMF terminals will be employed whenever connectivity requirements pose a problem. The XVIII Corps and the four divisions are scheduled to use the MSE system in their areas of operation beginning in 1992. This is almost 6 years after the GMF terminals are fielded in the XVIII corps.

Table 3-5. Army GMF SHF SATCOM Terminal Allocations for the Southwest Asian Theater

Echelon	Number of Terminals	
	TSC-85A	TSC-93A
Division (4)	8	12
Corps (1)	5	8
EAC	9	16
TOTAL	22	36

3.3.3 Korea

The AN/TSC-85A/93A architecture for Korea is based on the capability of the terminals to provide a low-capacity multichannel (6/12 channels) system at division and EAC levels. The terminals also have a range extension capability for selected use where there are terrain obstacles or other siting restrictions. In Korea, terminals will be deployed at the theater Army (EAC) and division levels as shown in Table 3-6.

Table 3-6. Army GMF SHF SATCOM Terminal Allocation for the Korean Theater

Echelon	Number of Terminals TSC-85A	TSC-93A
Division (1)	2	3
EAC	8	8
TOTAL	10	11

Although unconfirmed at this point in the study, indications are that the Army plans to field the AN/TSC-85A/93A terminals to Korea about 5 years before the MSE system would be used there. Thus, the GMF terminals, along with selected TRI-TAC equipment, will in effect provide the corps area multichannel systems until MSE is fielded.

CHAPTER 4
DESCRIPTION OF MOBILE SUBSCRIBER EQUIPMENT (MSE)

This chapter provides a technical and operational description of the MSE. Following an overview of the network architecture, technical descriptions are provided for the individual elements. The Ground Mobile Forces (GMF) super high frequency (SHF) satellite communications (SATCOM) technical interfaces with MSE components are then summarized. This is followed by an operational description of Army plans for employment of the system--first in a generic baseline case, and then as specifically applied to the European, Southwest Asian, and Korean theaters.

4.1 SYSTEM ARCHITECTURE

The MSE is a new system derived from TRI-TAC and Reseau Integre de Transmissions Automatique (RITA) equipment that is being deployed within the Army as the corps/division backbone communication system. It will integrate the functions of switching, radio trunking, communications security, and system control into one composite system. It is a circuit-switched network accommodating both fixed and mobile subscribers through the use of radio and cable netting. It employs a flood search routing algorithm that gives users the freedom to move within the network without changing telephone numbers. It also allows the network trunking to be reconfigured without the need to update routing tables in each switching element.

Figure 4-1 provides an architectural overview of the MSE system. The backbone network comprises node central switches (NCS) interconnected by digital transmission groups (DTGs) provided via radio frequency links (e.g., line-of-sight microwave radio). Two other types of switches, the large extension

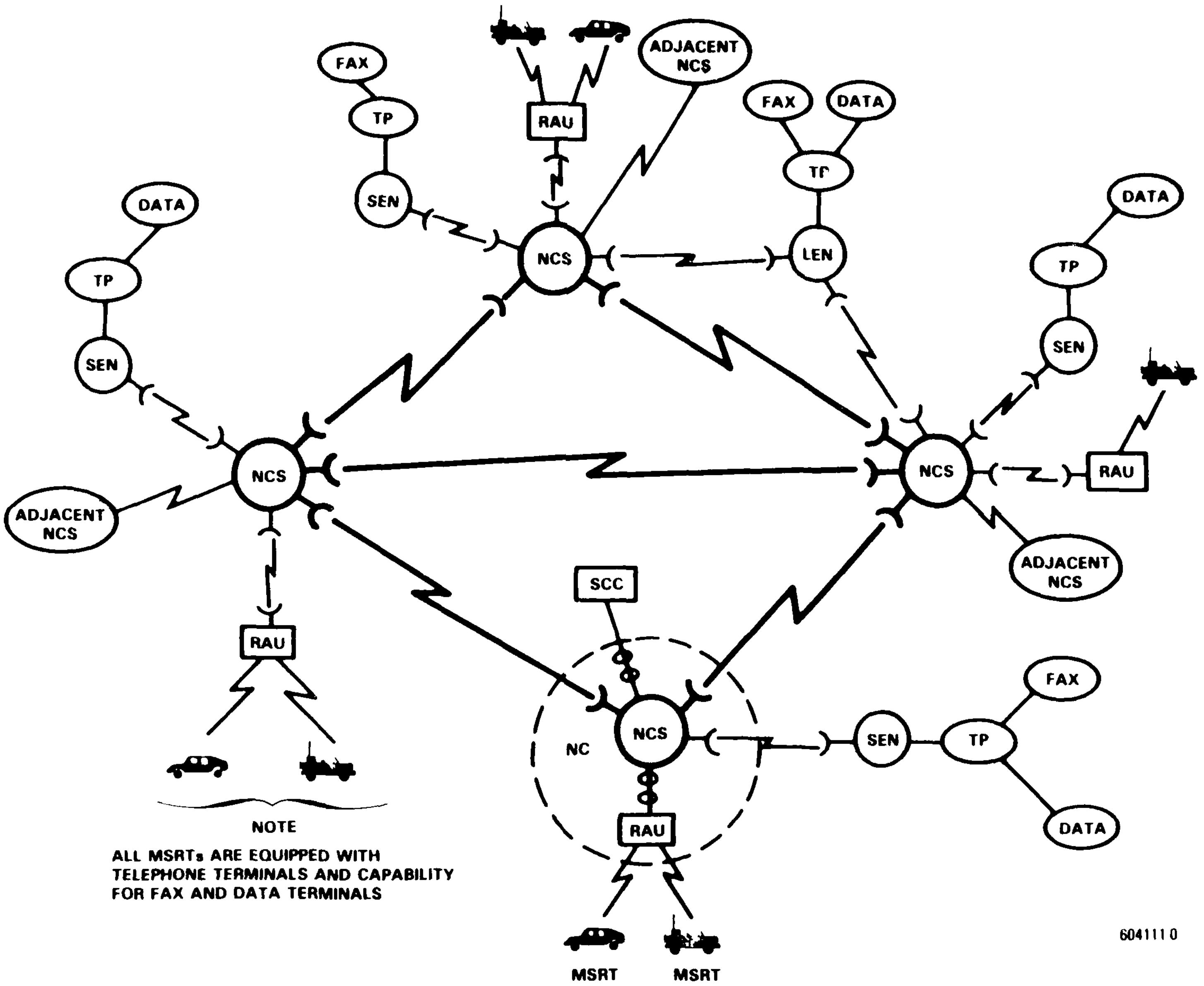

Figure 4-1. MSE Architecture

node (LEN) and the small extension node (SEN), connect to the NCS. These switches provide the primary means for fixed, wire-connected users to gain access to the network. The connections between the extension nodes and the NCS can be via cable or radio frequency link. Mobile users are provided access to the network via a radio access unit (RAU) associated with an NCS. The connection between the RAU and the NCS can also be cable or radio frequency link.

Several types of user terminals can be connected to the switches. The standard terminal for fixed, wire-connected users is the TRI-TAC digital nonsecure voice terminal (DNVT). For mobile users, the mobile secure radio terminal (MSRT) is used. Both of these terminals can accept input from facsimile or data terminals as well as voice.

The control and management of the network is provided by a system control center (SCC) connected to one of the NCSs.

Table 4-1 lists MSE functional areas and the equipment elements associated with those areas. A detailed description of the equipment is provided in the MSE system specification (Reference 3); however, to assist the reader in understanding the employment concepts described in this chapter, a summary description of the elements is provided here, emphasizing those features and characteristics that affect the use of satellite communications to support MSE.

4.1.1 Subscriber Terminals

Two basic types of subscriber terminals are provided with the MSE system: DNVTs and MSRTs.

The DNVT is a 4-wire digital telephone set that transmits and recieves digital voice and loop signaling at a rate of 16 kbps. It also includes a data adapter function and digital port to allow the use of compatible facsimile or data terminals, thus providing circuit-switched access to a variety of

Table 4-1. MSE SYSTEM COMPONENTS

MSE Component	Equipment Nomenclature
Subscriber Terminals	
Digital Nonsecure Voice Terminal (DNVT)	TA-954/M2
Mobile Subscriber Radio Terminal (MSRT)	ER-222/M2 with KY-68
Switches	
Node Central Switch (NCS)	AN/TTC-39
Large Extension Node (LEN)	AN/TTC-39
Small Extension Node (SEN)	SB-3614 ATD
Radio Access	
Radio Access Unit (RAU)	ER-222/M2
System Control	
System Control Centers (SCC)	Technical Control and Planning Shelters
Transmission	
Line of Site (LOS) Radio	GR-083ACT
Down the Hill (DTH) Radio	MF-15

data, record, and facsimile equipped users. These terminals connect directly to one of the MSE switching elements via individual cable pairs. These terminals can also be multiplexed into a DTG to access the switching element via coaxial cable.

The MSRT is a full-duplex radio linked telephone terminal that transmits and receives digital voice and loop signaling at a rate of 16 kbps. The MSRT provides radio link encryption and provides the same data adapter functions as the DNVT. The MSRT connects to the MSE network through an RAU at ranges up to 30 km for stationary users and up to 15 km for mobile users. MSRT users can also communicate directly with each other without the aid of the RAU if they are within radio range.

4.1.2 Mobile Subscriber Access

The RAU is used to connect MSRT users to an NCS. It consists of eight individual digital radio sets that provide the capacity for simultaneous use by eight MSRT users to communicate with other mobile and wire telephone users.

The RAU connects with an NCS either by cable or through an RF link. This link uses time-division multiplexing from the TRI-TAC multiplex structure to combine the individual circuits into a single DTG at 256 kbps. Figure 4-2 is a block diagram of the RAU.

4.1.3 Switches

The MSE system has three different types of switches: NCS, LEN, and SEN. The two extension nodes (LEN and SEN), with the RAU, provide the means to connect user terminals to the network. They also perform local switching among locally connected users. The extension nodes are connected to NCSs for access to users throughout the network. Connections between switches are by cable or through RF liks. These links use time-division multiplexing from the TRI-TAC multiplex structure to form DTGs with rates up to 1024 kbps. The following sections present a more detailed description of the MSE switches.

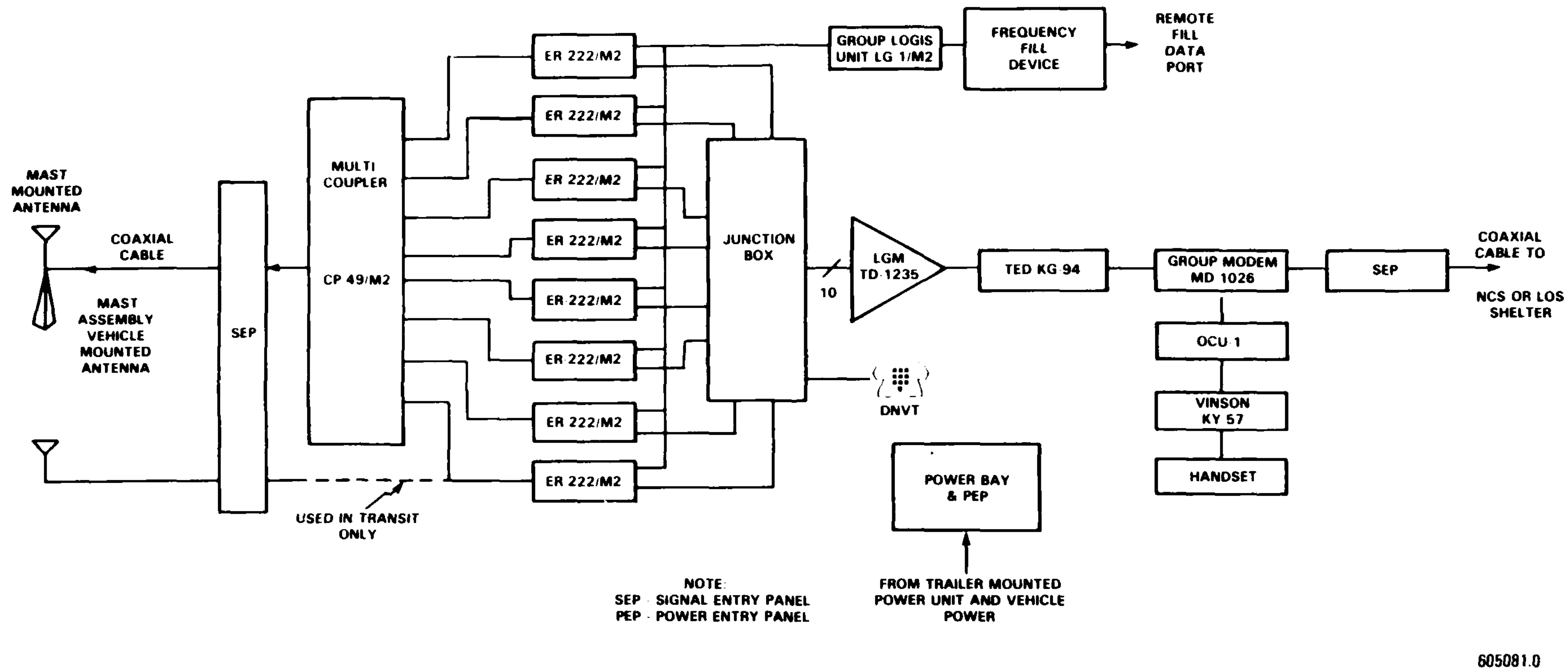

Figure 4-2. Radio Access Unit (RAU) Functional Block Diagram

4.1.3.1 Node Center Switch (NCS)

The NCS, the hub of the MSE system, is an AN/TTC-39 derivative switch that uses many of the AN/TTC-39 functions. However, the analog switching interface capabilities have been removed and the routing algorithm uses the RITA flood search capability to locate users throughout the network. This method differs significantly from the routing algorithm used in the TRI-TAC architecture, where each switch has a fixed directory and routing scheme to establish calls between users. (See Section 4.2 for a description of flood search routing.)

The NCS contains 16 DTGs, 15 of which are encrypted with the KG-94. A standard configuration for an NCS provides for four internodal (to other NCSs) trunk group clusters (TGCs) of 64 channels each (encrypted), six SEN TGCs of 32 channels each (encrypted), and two RAU TGCs of eight channels each (local RAU unencrypted and remote RAU encrypted). Additionally, it has four unassigned DTGs that can be assigned to any combination of NCS, LEN, SEN, or RAU TGCs based on the system's operational requirements.

The NCS provides about 400 trunk terminations for connections between switches in the MSE network and acts as a gateway to TRI-TAC and NATO switches. Figure 4-3 is a functional block diagram of the NCS.

4.1.3.2 Large Extension Node (LEN) Switch

The LEN switch is an AN/TTC-39 derivative digital switch enhanced with RITA features to handle subscriber affiliation and saturation signaling. It is similar to the NCS, but has a reduced trunking capability and an increased subscriber line capacity. The LEN switch serves about 150 digital wire

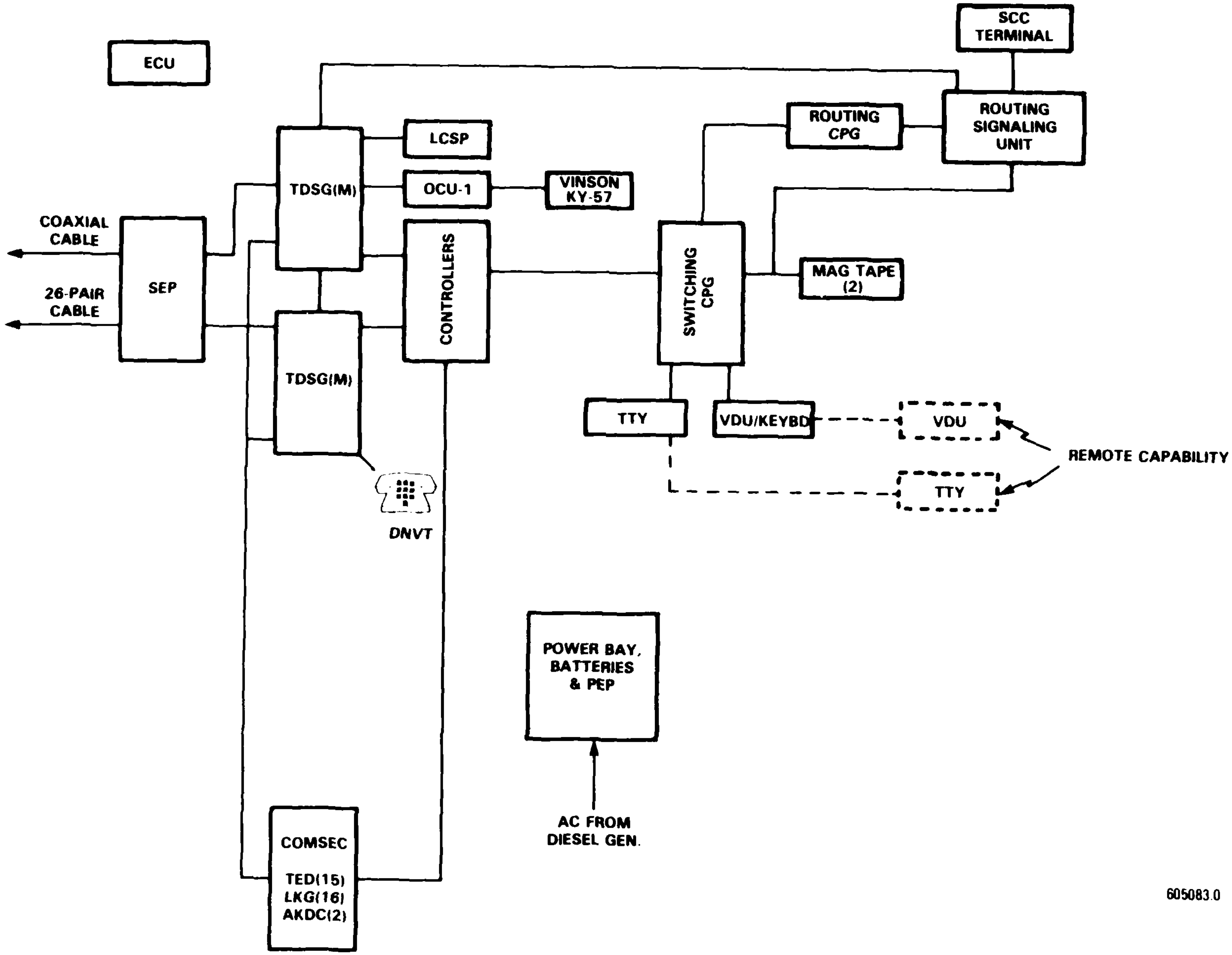

Figure 4-3. Node Center Switch Block Diagram

subscribers connected either by DTGs or by individual cable pairs. Subscribers can directly dial any other subscriber in the MSE network. Subscriber management and affiliation of the connected subscribers are performed locally. The LEN interfaces with combat net radios via a net radio interface unit. It also provides an interface to commercial networks on an analog basis.

In a normal configuration, two different DTGs (secure) from each LEN are assigned to two different NCSs. The LEN is equipped with a total of eight DTGs, three of which are encrypted using KG-94s. Figure 4-4 is a block diagram of the LEN.

4.1.3.3 Small Extension Node (SEN) Switch

The SEN switch uses two SB-3614 derivative automatic analog switches. It has AUTOVON tandem switching and digital capabilities. There are two versions of the switch, V1 and V2. V1 has 26 digital subscriber terminations and is normally deployed with battalions, while V2 has 41 digital subscriber terminations and is typically deployed with brigades. The SEN provides an analog interface capability for the MSE system. It is equipped with one encrypted digital trunk group that can be assigned to an NCS or to an LEN. Figure 4-5 is a block diagram of the SEN.

4.1.4 Transmission

4.1.4.1 Line-of-Sight (LOS) UHF Radio Assemblages

LOS radio links are established between node centrals and from a node central to each affiliated extension node and remote RAU. Each LOS transmission link is encrypted. The

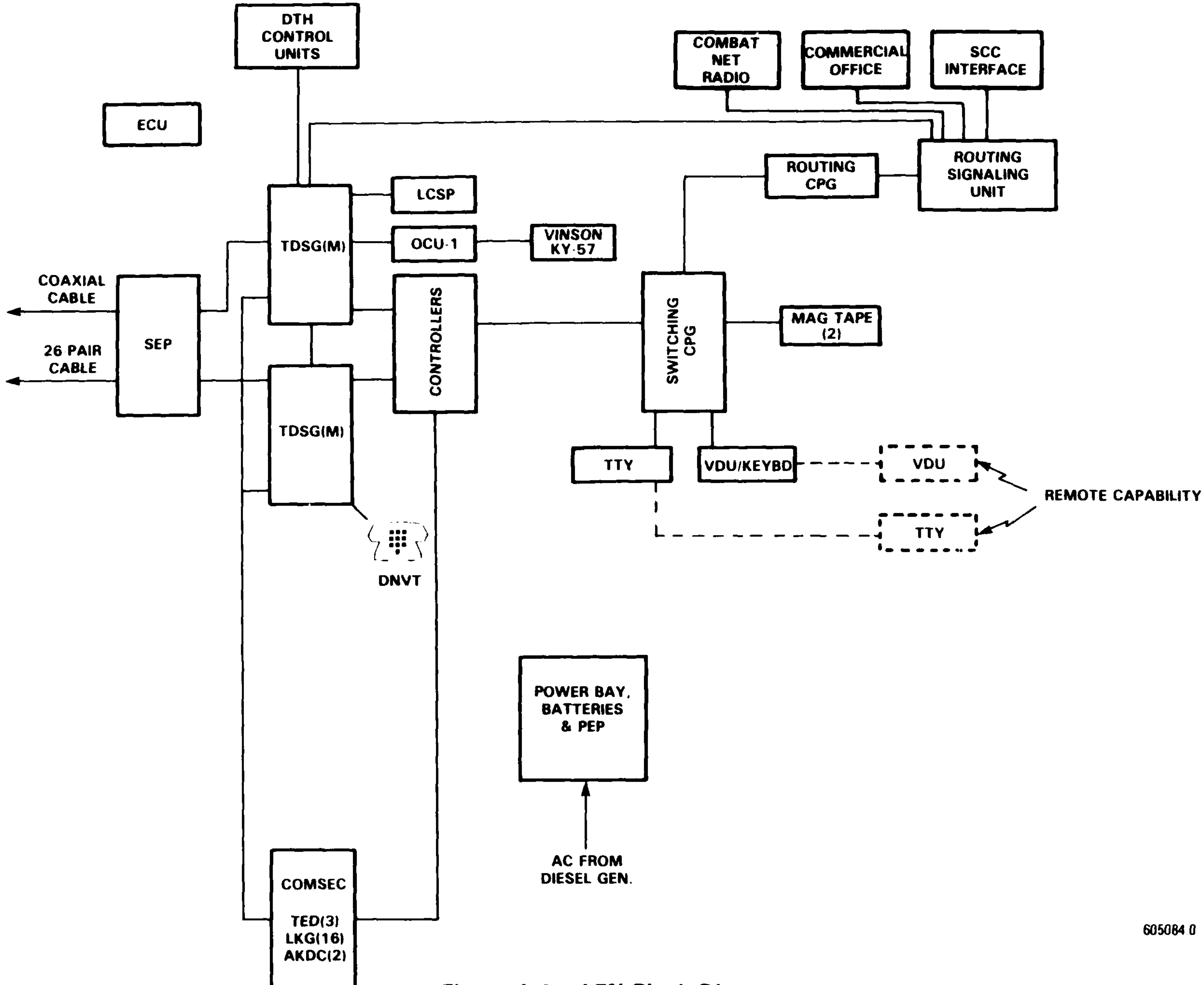

Figure 4-4. LEN Block Diagram

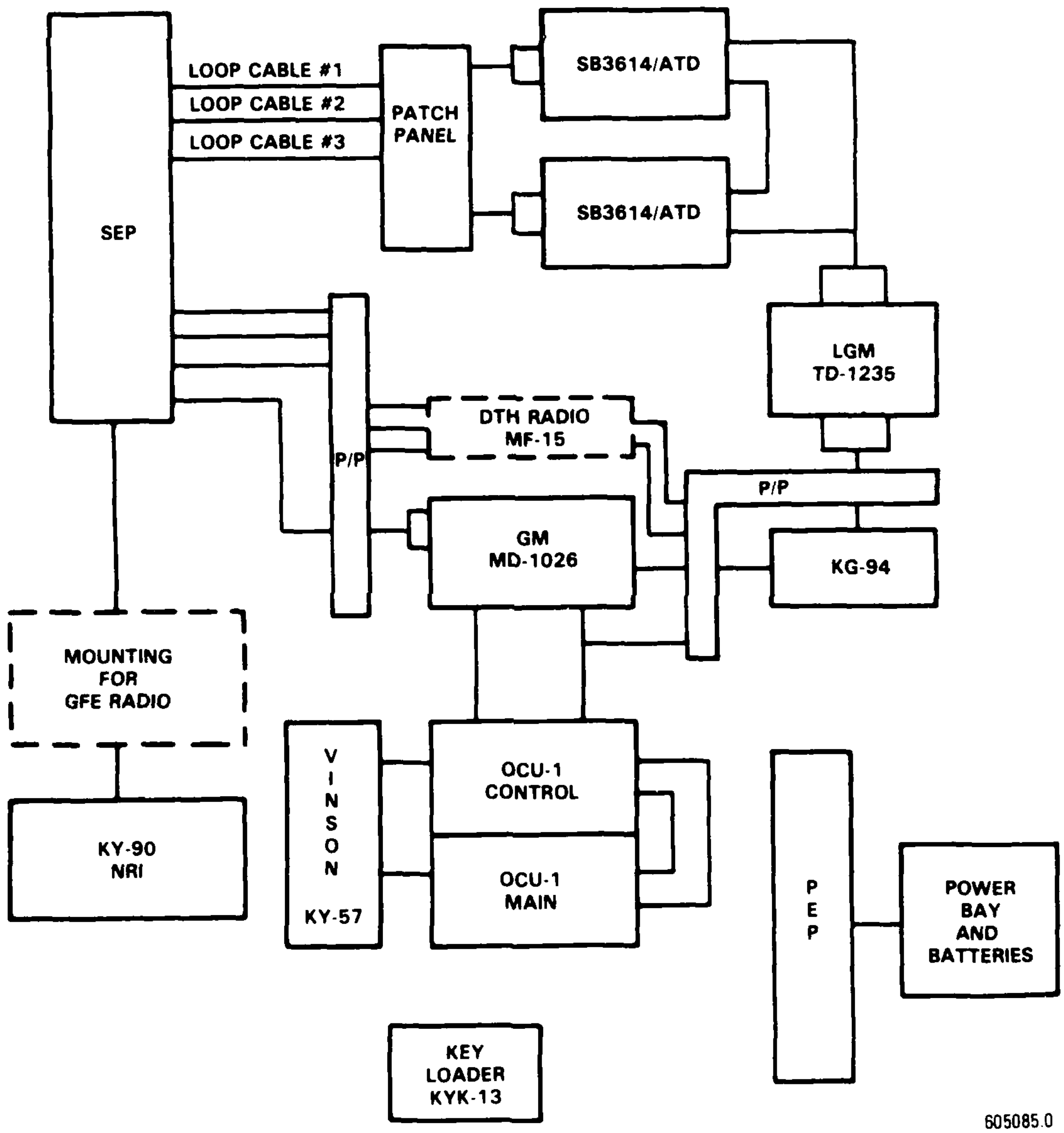

Figure 4-5. Small Extension Node (SEN) (V1, V2) Functional Block Diagram

transmission equipment consists of components of the digital group multiplexer (DGM) family of equipment. The LOS radio covers two frequency ranges: band A (220 to 405 MHz) and band B (1350 to 1850 MHz). Four versions of LOS radio assemblages (V1 through V4) are used in MSE systems for the following applications:

- V1--RAU/SEN
- V3--Node central
- V4--LEN
- V5--NATO interface.

The V1 assembly provides a digital LOS terminal link between a SEN or RAU and one NCS using two LOS radios (GR-083ACT) and one antenna mast. It can support a data rate of 256 kbps.

The V3 assembly consists of three LOS radios and a down-the-hill (SHF) radio in each terminal that provide radio terminal capability for the node centrals. It can support a data rate of 1024 kbps.

The V4 assembly provides two digital LOS terminal links between the LEN and two NCSs using two LOS radios and two antenna masts. It can support a data rate of 512 kbps.

The V5 assembly consists of two LOS radios and one antenna mast and is used with terminals at NATO interfacing locations. It can support a data rate of 256 kbps.

4.1.4.2 Down-the-Hill (DTH) Radio (SHF) Equipment

The DTH radio (MF-15) consists of an RF unit and a control unit. The RF unit is antenna mounted and contains a

transmitter and receiver. The control unit is shelter mounted and can be located up to 200 m from the RF unit. This radio system operates in the 14.50- to 15.35-GHz frequency range and has 8 sub-bands (98 MHz per sub-band). These radios are deployed with SENs and LENs.

4.1.5 Network Control

4.1.5.1 System Control Center (SCC)

The MSE system will be controlled by an SCC. The SCC is configured into two functional areas: technical and management. The SCC is responsible for network organization and reconfiguration, asset management, and LOS transmission link engineering. Link engineering includes siting radios for optimum location, azimuth, optimum frequencies, and signal-to-noise ratio. Presumably the SCC would also be responsible for determining the need for satellite links and for initiating a request to the GMF network controller. A single SCC is planned to manage a total corps and division network, up to 56 nodes. The SCC managing the network is to be connected to one NCS while a fully redundant standby SCC would be connected to a different NCS. The standby SCC would assume control of the network when required. The SCCs provide automated near-real-time directives, reports, and data base information exchange and distribution. This is accomplished using the switched network between the SCC and NCSs and between the redundant SCCs. While only one SCC is needed to control an entire corps/division network, an SCC is also deployed in each division area. The division SCCs provide the divisions a stand-alone capability and, when installed as part of the total integrated corps/division MSE system, these SCCs are operated in a "slave" mode.

4.2 CALL ROUTING

The MSE network employs a flood search routing algorithm to search for a called user. This is quite different than most circuit switched networks, which use finite routing tables located at each switch that point to the route to be used depending on the dialed number. This difference allows users to move within the network and to retain their original phone number. It also allows the network trunking to be reconfigured without changing routing tables in all the switches.

MSE uses two distinct event sequences to establish a call in the network. The first deals with finding the dialed user and selecting the path to be used; the second actually connects the two users. Each of these sequences uses a separate communications channel to allow communications between the two separate processors in each switch.

The first sequence of events consists of three phases as shown in Figure 4-6. In the search phase, the switch associated with the originating user transmits a search message containing the phone number of the called user on every link connected to another network switch. Each switch that receives the search message retransmits it on every link except the one on which it received the message. Obviously, each switch will receive multiple search messages for the same call; however, only the first such message that is received results in any action by the receiving switch. All other messages are ignored.

In order to speed up the search process so that each node doesn't delay the search while it checks its own subscriber list, the receiving switch checks to see if the called user is connected to it after forwarding the search message. If it is,

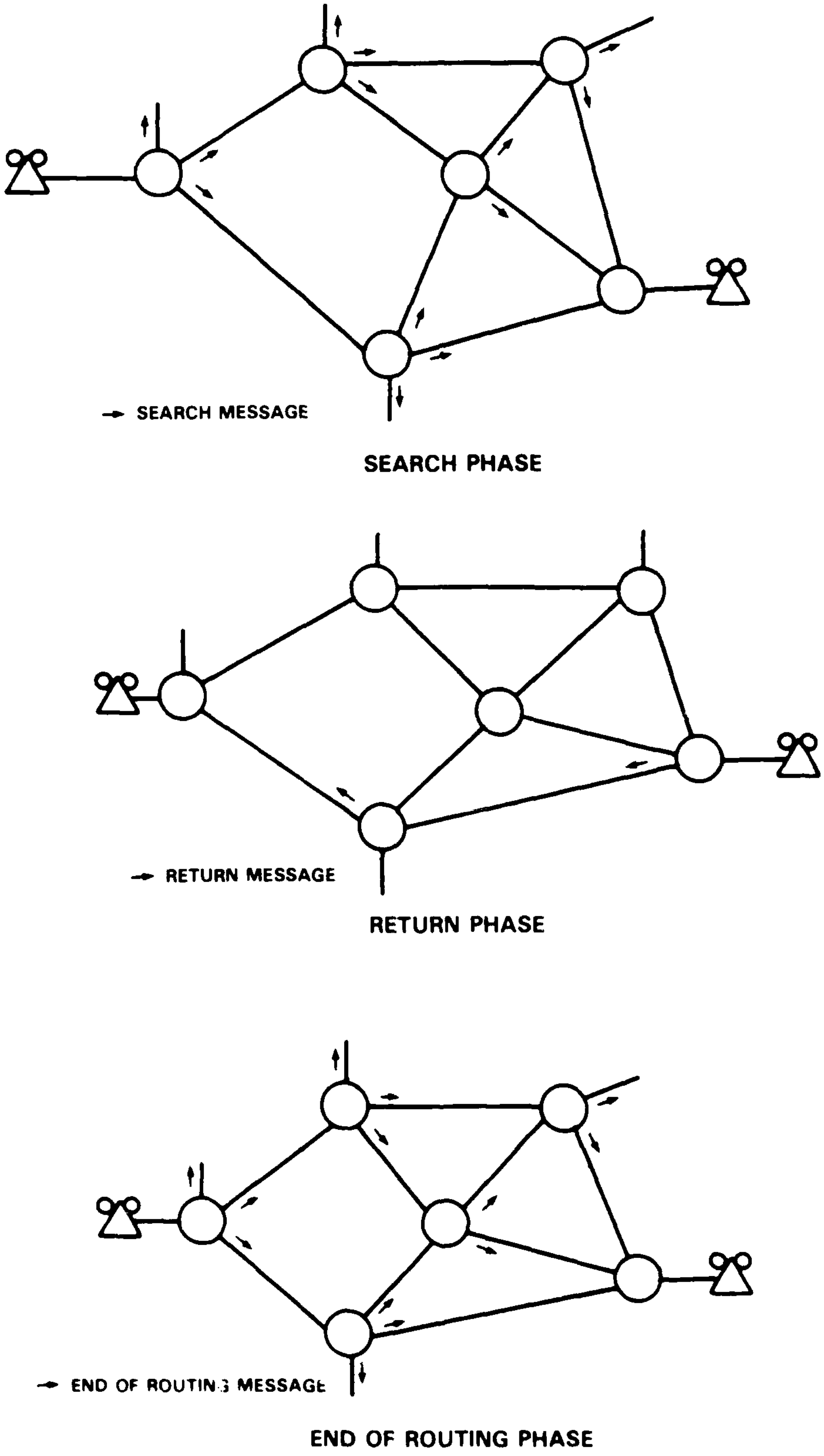

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Figure 4-6. Flood Search Routing

the second phase of the process is begun. The switch that finds the called user generates a return message and sends it back to the switch from which it received the first search message. Each switch that receives this return message marks the route on the link and continues to return the return message toward the calling user. When the originating switch receives the return message, it transmits an end-of-routing message on all links. This completes the first event sequence.

The next sequence uses a separate communications channel to attempt to complete the call over the path marked in the first sequence. It also uses a set of forward and return messages to establish the talking path between the calling and called user.

In the case where a call is destined to a user outside the MSE network or in another MSE network, the same procedure is used except that the search is for an MSE gateway switch to that other network rather than for a particular user. The other networks are identified by using an area code preceding the actual user phone number.

Two important points can be made about the preceding discussion. The first is that two separate overhead or signaling channels are required on all TCGs between NCSs and between NCS and LEN pairs. These channels are dedicated to specific processors within each switch and cannot be used for user traffic. The second point is that, because the first search message received by a switch determines the path through the network, links that employ satellites will necessarily be chosen last because of the long transmission delay inherent in these links. The significance of these points is discussed in Chapter 5.

4.3 EQUIPMENT INTERFACES

This section focuses on the interface characteristics of four primary nodes in the MSE system that are potential SATCOM interface points: the NCS, LEN switch, SEN switch, and RAU. Table 4-2 summarizes the interface characteristics between principal elements of the MSE system. In addition, the bit rates required to interface with GMF SATCOM are indicated.

The NCS provides interfaces for up to 16 DTGs, which are multiplexed as shown in Figure 4-7. Multiplexer input 2, 3, and 4 accept group rates of 256 kbps, 512 kbps, or 1024 kbps. Input 1 accepts groups of 256 kbps or 512 kbps. The output of the multiplexer is fixed at 4096 kbps. For each multiplexed group, an orderwire interface is provided at the modem or SHF radio. Groups that interface the LEN, SEN, remote RAU, and other NCSs are bulk encrypted using KG-94. Groups to the SCC and local RAU are not bulk encrypted. The DTGs use conditioned diphase modulation when transmitting via direct CS-11230 cable connection or via the LOS radio system.

AN/TSC-85A or AN/TSC-93A satellite terminals can be used to interface the NCS with other NCSs, LENs, and SENs. The NCS-to-NCS satellite link is at 1152 kbps using 64 channels. The NCS satellite link to an LEN operates at 576 kbps (32 channels) and the satellite link to an SEN operates at 288 kbps (16 channels).

The LEN interfaces with the NCS and SEN switches via LOS radio links or coaxial cable. Digital subscriber terminals, remote multiplexer combiners (RMCs), the SCC, and AN/TSC-85A or AN/TSC-93A satellite terminals access the LEN using coaxial cable. A DTH radio link can be used to locate the LOS terminal in an area remote from the LEN.

Table 4-2. MSE Element Interfa(e Characteristics

	NCS	LEN	SEN	RAU
NCS	1024 kbps CDI, CCS TED	512 kbps CDI, TED CCS	256 kbps CDI, TED DIBTS	256 kbps CDI, TED DIBTS
LEN	512 kbps CDI, CCS TED	–	256 kbps CDI, TED DIBTS	–
SEN	256 kbps CDI, TED DIBTS	256 kbps CDI DIBTS	–	–
RAU	256 kbps CDI, TED DIBTS	–	–	–
SCC	256 kbps CDI	256 kpbs CDI UNENCRYPTED	–	–
DTH	256/512 1024/4096 kbps, TED BASEBAND	512 kbps BASEBAND TED	256 kbps BASEBAND TED	–
LOS	(V3) 256/512/1024 Kpbs, CDI TED	(V4) 512 kbps CDI, TED	(V1) 256 kbps CDI, TED	(V1) 256 kbps CDI
DNVT OR DSVT	16 kbps CDI DIBTS	16 kbps CDI DIBTS	16 kbps CDI DIBTS	–
SATCOM	1152 kbps 64 CHANNELS	576 kbps 32 CHANNELS	288 kbps 16 CHANNELS	–

CDI - CONDITIONED DIPHASE MODULATION
CCS - COMMON CHANNEL SIGNALING
TED - TRUNK ENCRYPTION DEVICE
DIBTS - DIGITAL INBAND TRUNK SIGNALING

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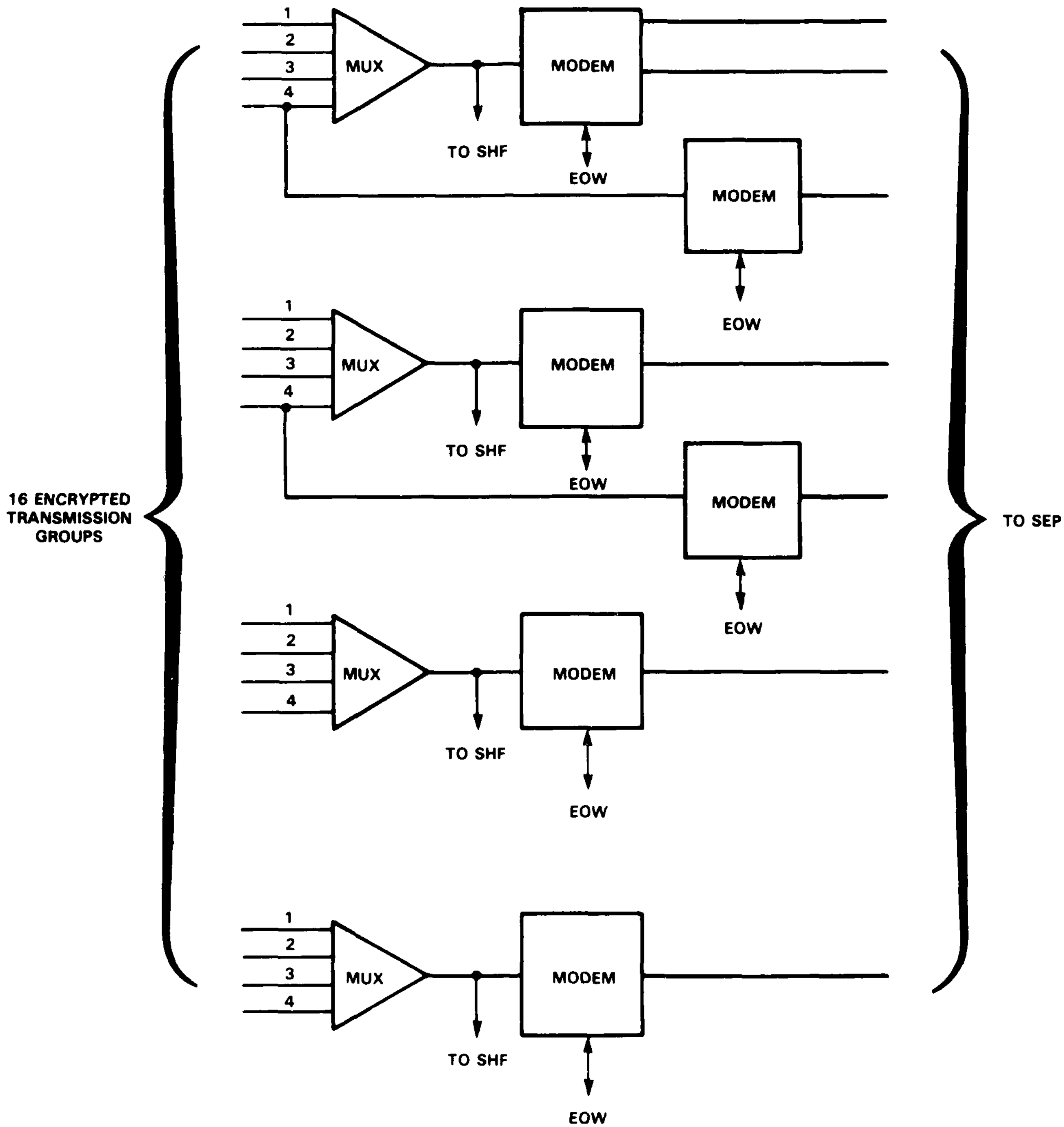

Figure 4-7. NCS DTG Interfaces

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The LEN provides interfaces for up to eight DTGs, three of which are bulk encrypted. The remaining five are unencrypted. The DTGs use conditioned diphase modulation when transmitting via direct cable connection or via the LOS radio system. When a DTH is employed, the group is patched directly from the trunk encryption device (TED) to the DTH radio controls. An orderwire access is provided to each group.

The LEN multiplexes 10 or 13 digital inband trunk signaling (DIBTS) terminations (V1 and V2, respectively) into a conditioned diphase 256-kbps encrypted DTG for transmission to the SEN. The NCS trunk group is a 512-kbps group containing 32 trunk channels.

The LEN provides DTG interfaces to the AN/TSC-85 and AN/TSC-93A TACSAT terminals. Traffic destined for an SEN forms a 288-kbps group with 10 (V1)/13 (V2) channels used as trunks, 1 used for framing and 7 (V1)/4 (V2) channels unused. The LEN TACSAT link to an NCS operates at 576 kbps. Thirty channels are used for signaling, and four channels are unused.

The SEN is equipped with one encrypted DTG that can be connected to an NCS or to an LEN using LOS radio links, satellite links, or coaxial cable. The DTH radio (MF-15) can be used to locate the LOS terminal in an area remote from the SEN.

The SEN functions as an EPBX for wire subscribers and combines all full-duplex, single-channel, 16-kbps DIBTS terminations into a conditioned diphased 256-kbps encrypted DTG for transmission to the LOS radio, or to an NCS or LEN over CX-11230 dual coaxial cable. There are 10 and 13 trunk channels, respectively, for the V1 and V2 versions. When the

DTH radio is used, the group is patched directly from the TED to the DTH radio controls, bypassing the group modem.

The SEN can also multiplex the trunks into a conditioned diphase 288-kbps encrypted DTG for connection to the AN/TSC-85A or AN/TSC-93A satellite ground terminals.

The RAU concentrates mobile subscriber traffic to the NCS by multiplexing nine full-duplex digital data lines (the eight RAU radio lines and a DNVT orderwire) each at 16 kbps, into a single high-speed digital signal pair at 256 kbps. The loop group multiplexer (LGM) multiplexing scheme is summarized in Table 4-3. Transmission to the NCS is via a CX-11230/G cable or LOS radio link. The transmission group is KG-94 encrypted. Conditioned diphase loop modulation is employed.

Table 4-3. TD-1235 Multiplexer (LGM) Characteristics

Feature	Characteristics	
No. of Channels	7, 8, 15 or 16	
Channel Bit Rate	16 or 32 kbps	
Channel Interface		
Modulation	Cond. Diphase	
Field Wire	WF-16 (2.0 mi)	
Group Bit Rates:	16 kbps	32 kbps
7 channel	128	256
8 channel	144	288
15 channel	256	512
16 channel	288	576
Group Interface		
Signals	NRZ data and square wave clock	
Cable	RG-108 (100 ft.)	

The MD-1026 group modem provides the standard TRI-TAC interface through the signal entry panel (SEP).

4.4 MISSION/OPERATIONAL DESCRIPTION OF MSE

The MSE system is being acquired by the Army to meet requirements at corps and division levels for an integrated area common user system that will provide voice, data, and record traffic over a system that is secure, flexible, reliable, and survivable. MSE is to provide static and mobile users a capability to communicate throughout the battlefield, regardless of location. The MSE system must also interoperate with the combat net radio, TRI-TAC, DCS, NATO, commercial, and GMF(SHF) SATCOM networks. The MSE-GMF(SHF) SATCOM interoperation is the focus of this study.

4.5 BASELINE OPERATIONAL CONFIGURATION

The MSE system baseline is centered on the operational deployment of a three-division peacetime corps force with a buildup to a five-division wartime corps. A picture of a generic five-division corps network is shown in Figure 4-8. Such a network would be composed of 56 interlinked nodes, 36 deployed by the corps signal brigade and 20 deployed by the division signal battalions supporting the divisions. Nodes are normally separated by 25 km. In the baseline system, each node is connected to other nodes using LOS radio, although other transmission media are possible. The resulting grid network provides coverage of a corps area of operations of approximately 37,500 km^2 (250 km by 150 km). Deployment, installation, and operation of the nodes would be accomplished by signal corps units assigned to the corps/divisions. Actual nodal deployments would be based on the density of subscribers in particular areas and terrain considerations. The Army does not expect that 56 NCSs would be operational at all times or

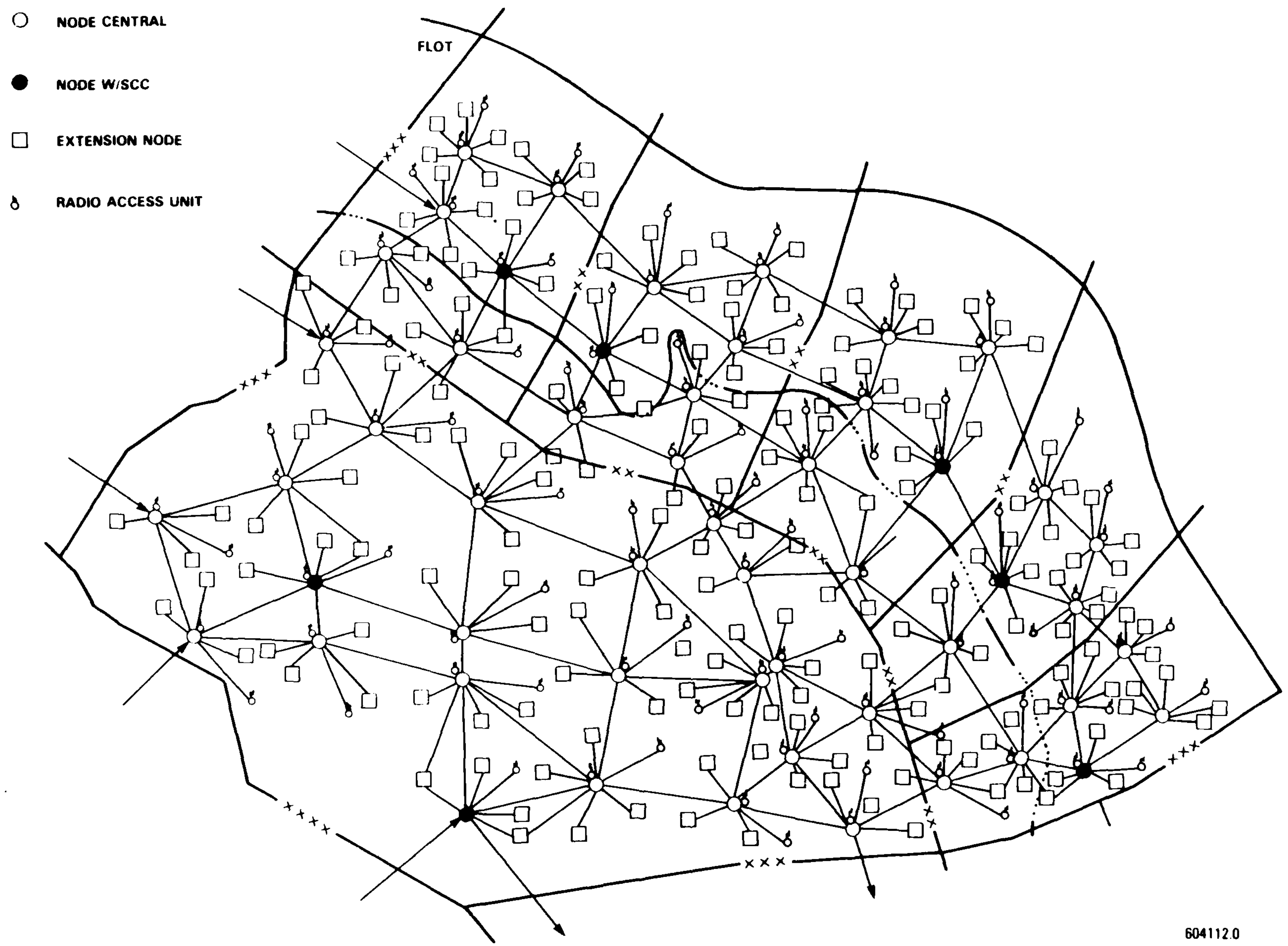

Figure 4-8. The MSE System Deployed in a Corps Configuration

that subscribers will be uniformly distributed within the assigned corps boundaries. A typical deployment of MSE in a division area is shown by the shaded area in Figure 4-9. Note connectivity to the remainder of the corps system. MSE grid networks will vary based on subscriber densities that would occur in actual geographic deployments of the subscribers. In addition, corps signal brigade MSE assets will be forward deployed into the divisions' areas of operations, effectively integrating the network to provide the required area coverage.

MSE components will be distributed as "sets" to the Army users. Table 4-4 shows the allocation of the major MSE components for three force levels.

Table 4-4. Operational Configurations of Mobile Subscriber Equipment

MSE Component	Force Levels: 1 Division	3 Divisions	5 Divisions
Subscriber Terminals			
MSRT	685	1597	1900
DNVT	1080	4320	6200
Switches			
NCS	4	39	56
LEN	1	6	8
SEN	16	166	224
RAU	9	84	120
SCC	2	8	12

As mentioned above, the MSE system will be deployed in a large grid network normally to support a three- to five-division force. However, there is the capability to provide

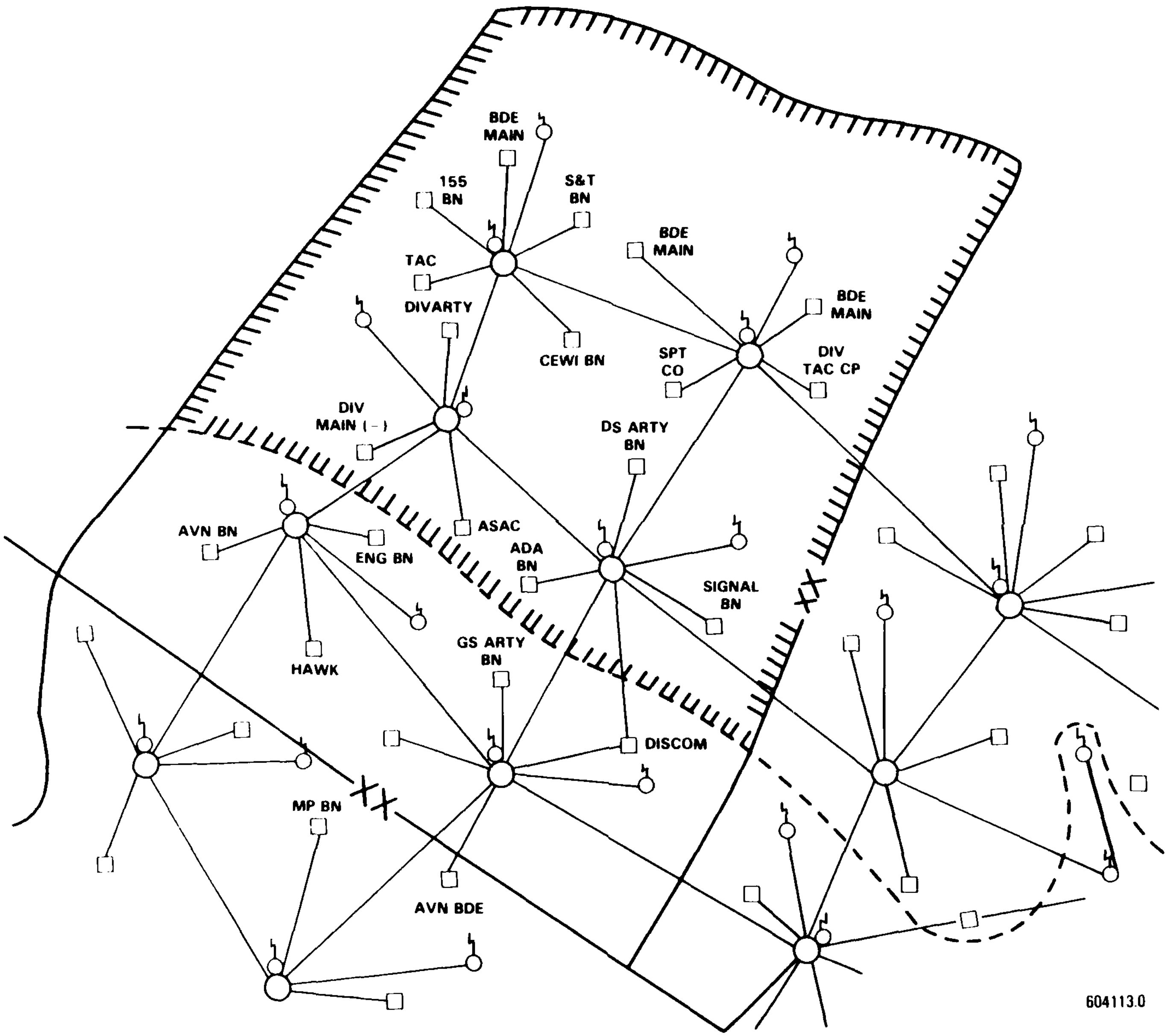

Figure 4-9. The MSE System Deployed in a Division

support to a single division. The division signal battalion would deploy the MSE assets (excluding subscriber terminals) and provide NCSs at division main and at each of the maneuver brigade command posts. Sixteen SENs would be clustered around four NCSs, to serve up to 685 mobile subscribers and 1080 stationary subscribers. RAUs would also be deployed to meet requirements of maneuver forces, including armored cavalry units conducting screening operations in front of main forces. A single SCC would be deployed as the master for system control, with another SCC in a standby mode. The MSE assets for a division-size force will only be sufficient to provide minimum connectivity until a larger (three- or five-division) force is deployed with its MSE equipment from the corps signal brigade. As discussed later, scenarios that call for deployment of a single division for extended periods of time may require the capabilities of GMF(SHF) SATCOM to meet operational requirements until additional MSE assets are available.

In contrast to the single-division force, a three-division corps will contain almost 10 times the number of NCSs, extension nodes, and RAUs to provide service to approximately 1600 mobile subscribers and over 4000 stationary subscribers. Four times as many SCCs will also be available. This difference in the number of assets is due to the addition of a signal brigade with three signal battalions to the corps support forces. In this configuration, MSE assets are integrated into a communications network in which the corps/division communication support boundaries are indistinguishable.

In the five-division corps force, MSE assets are available to deploy 56 NCSs, over 40 percent more than in the three-division configuration. The number of extension nodes is increased by 60 (34 percent), the RAUs by 36 (42 percent), and the system control elements from 8 to 12 (50 percent). These additional assets are used to service a potential 8100

subscribers, an increase of 2283 (37 percent) over the three-division force.

4.6 THEATER OPERATIONAL CONFIGURATIONS

In the previous section, the MSE system was described in terms of baseline configurations of one, three, and five divisions. This section focuses on the applicability of those configurations to support Army operations. The theaters considered are Europe, Southwest Asia, and Korea.

4.6.1 Europe

In peacetime the Army has five divisions deployed in the central region of Germany. The five divisions are under the control of two corps (V and VII). In wartime, V Corps will be increased to be configured as a three-division force and VII Corps will be increased to five divisions. In wartime, additional corps (Corps I and III, with three and five divisions, respectively) will join the forward deployed forces. Table 4-5 depicts the major MSE components assigned to each corps, based on the number of wartime divisions.

Table 4-5. Allocation of MSE Components to Corps Assigned to the European Theater

MSE Component	I Corps 3 Div	V Corps 3 Div	VII Corps 4 Div	III Corps 5 Div
Subscriber Terminals				
MSRT	1597	1597	1747	1900
DNVT	4320	4320	5260	6200
Switches				
NCS	39	39	44	56
LEN	6	6	7	8
SEN	166	166	182	224
RAU	84	84	102	120
SCC	8	8	10	12

Geographical distances and terrain siting considerations should be relatively minor considerations in the MSE deployments to Europe, given the force size and the amount of MSE equipment that can be deployed. However, if the number of divisions assigned to particular corps is less than three, structuring the MSE network for optimum performance and survivability will be a major issue.

4.6.2 Southwest Asia

Army forces are not currently forward deployed in Southwest Asia. However, four divisions with a controlling corps headquarters are designated as forces to be deployed there in the event of hostilities. Allocations of MSE components for this corps are shown in Table 4-6. If less than the full corps were deployed, then the MSE system would also be reduced.

Table 4-6. Allocation of MSE to the XVIII Corps Assigned to the Southwest Asia Theater

MSE Component	XVIII Corps (4 Divisions)
Subscriber Terminals	
MSRT	1747
DNVT	5260
Switches	
NCS	44
LEN	7
SEN	182
RAU	102
SCC	10

It should be pointed out that the XVIII Corps area of operations is three to five times larger than in Europe and several of the Army divisions scheduled for Southwest Asia deployment will operate over distances exceeding the planning figures for MSE network operations. In addition, mountainous terrain could be an obstacle to the use of MSE in this theater. Finally, if fewer than four divisions are deployed, the MSE network will require careful planning to ensure adequate coverage of the corps area of operations.

4.6.3 Korea

The Army has one division forward deployed in Korea for peacetime deterrence. The division signal battalion is currently the only unit scheduled to receive MSE in Korea. Allocation of MSE components to this division is given in Table 4-7.

Table 4-7. Allocation of MSE Components to the 2ND Division in Korea

MSE Component	2nd Infantry Division
Subscriber Terminals	
MSRT	685
DNVT	1080
Switches	
NCS	4
LEN	1
SEN	16
RAU	9
SCC	2

As stated in the O&O plan, deployment of a single division set of MSE is viewed as a means to provide only initial communications network, not a sustained level of acceptable communications support for a standalone division. This is because the MSE system depends on the capability for subscribers to access multiple nodes to obtain the required connectivity, capacity, and survivability. In a static environment, four interrelated nodes would be sufficient to provide support to a single division. However, under the AirLand Battle doctrine, units will disperse and move frequently. A four-node system is not expected to have the flexibility to adjust to fast-moving tactical operations. Currently the Army Signal School has proposed that two additional NCSs (and an area signal company) be added to the 2nd infantry division signal battalion to increase the flexibility of the MSE network supporting that division.

CHAPTER 5

UTILIZATION OF GMF TERMINALS WITH MSE

Chapter 3 discussed the current Army plans for employing ground mobile forces (GMF) super high frequency (SHF) satellite communications (SATCOM) terminals in Europe, Southwest Asia, and Korea. Chapter 4 discussed the planned employment of MSE in these same theaters. This chapter addresses documented and (in some cases) implied utilization of the GMF capabilities in support of the mobile subscriber equipment (MSE) system as determined by the study team's review of selected Army documents. An analysis of the usage concludes this chapter.

5.1 DOCUMENTED SCENARIOS FOR THE USE OF GMF(SHF) SATCOM WITH MSE

The study team reviewed both the GMF SATCOM and the MSE operational and organizational (O&O) plans (References 4 and 5) and used these as primary sources to document scenarios in which GMF SATCOM was projected to be used in conjunction with the MSE system. The team also developed scenarios by adapting the O&O material to current Army thinking, as reflected in U.S. Army Signal School briefing material on SATCOM/MSE support to operational missions.

The GMF O&O plan states that the AN/TSC-85A/93A terminals will be used in various network configurations to provide a communications overlay capability to the MSE system. Specifically, the terminals will be employed to: (1) provide point-to-point communications between selected command posts; (2) extend the range of line-of-sight (LOS) communications; (3) provide a capability to bypass (skip nodes) portions or sections of the network and provide communications service directly to echelons above corps (EAC); (4) provide trunks between MSE nodes that otherwise would not be connected due to distance or siting restrictions on the MSE LOS transmission

system. In effect, the GMF O&O phase provides general areas where SHF SATCOM can be used to enhance MSE but does not provide any specific details, in terms of SATCOM network configurations or theaters of operation.

The MSE O&O plan states a requirement for the GMF SHF terminals to be interoperable with the MSE system at node centrals, large extension nodes (LENs), and small extension nodes (SENs). However, no specific scenarios are cited in which the two systems would be used in conjunction with each other. However, scenarios are currently being developed by the U.S. Army Signal School to address the use of GMF(SHF) SATCOM with MSE. These scenarios are deep battle, skip echelon, and enclave connectivity. They are discussed below.

5.1.1 Deep Battle

The AirLand battle doctrine places major emphasis on the use of maneuver forces to conduct tactical operations in enemy rear areas. These forces would have missions to delay, disrupt, or destroy enemy follow-on forces before they arrive at the main battle area, near the forward line of own troops (FLOT). The maneuver forces can be up to division size and would most likely be under the command and control of a corps headquarters. This scenario is depicted in Figure 5-1. The division, operating in enemy territory, would require multichannel connectivity to its controlling corps headquarters.

It is unlikely that the division carrying out the deep attack will fully employ its MSE assets, but rather would use selected components (e.g., NCSs, RAUs). The AN/TSC-85A/93A terminals would probably be interconnected at the NCS serving the division headquarters and provide the transmission link to the NCS servicing the corps headquarters in friendly territory. In effect, the GMF SATCOM capabilities would provide the connectivity between a small MSE network with the attacking

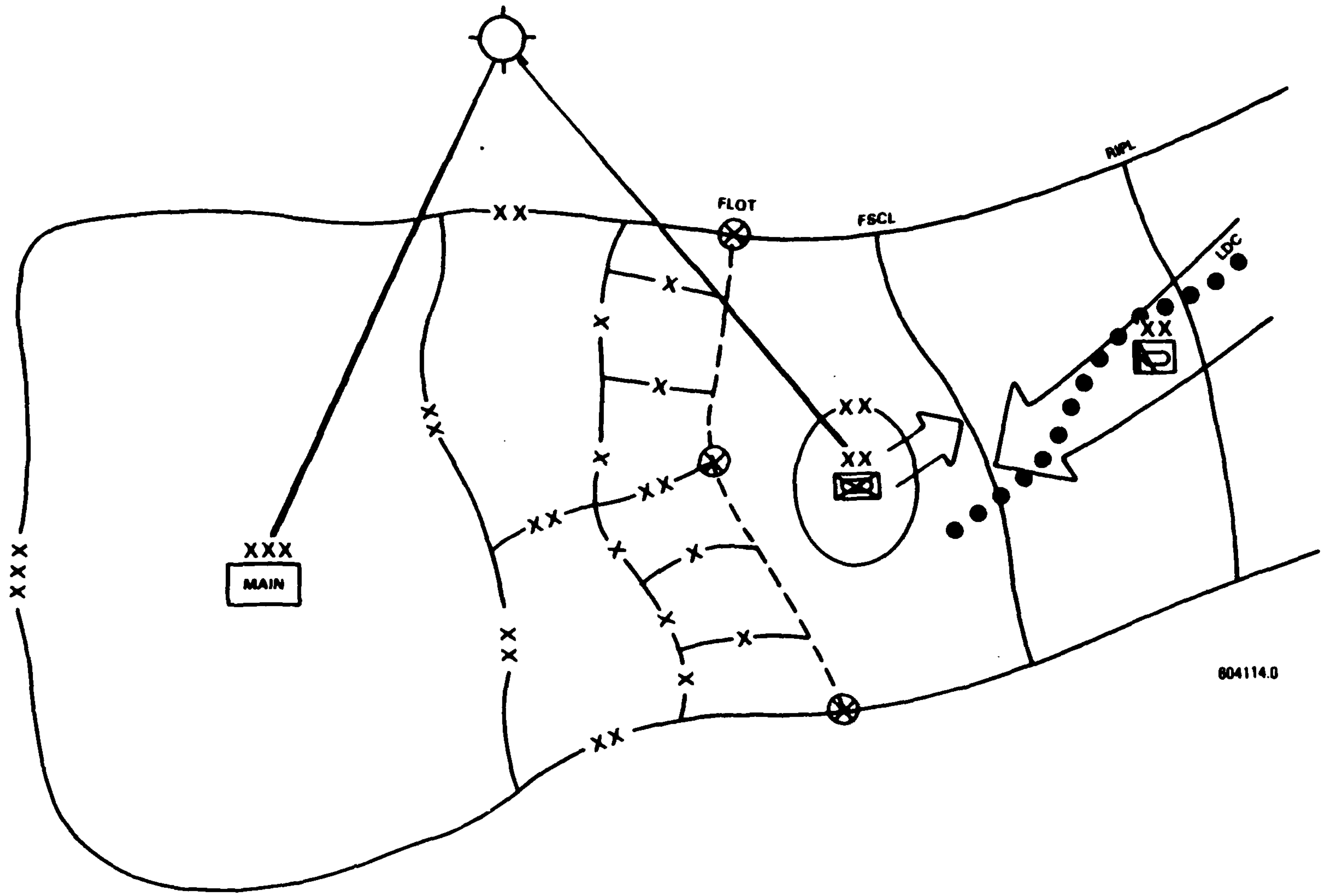

Figure 5-1. Deep Battle

division and a full corps MSE network. Deep battle is an AirLand battle scenario applicable to all theaters.

5.1.2 Skip Echelon

The skip echelon scenario is designed to interconnect units (e.g., divisions) at one echelon to units/headquarters one or more levels higher. For example, for selected missions, a division may require direct communications connectivity to an EAC headquarters (e.g., theater). This concept is portrayed in Figure 5-2. In the skip echelon scenarios, the AN/TSC-85A/93A terminals would provide the necessary long-haul trunking between the area systems at the two affected nodes (e.g., division, theater). At the division level, the SATCOM terminals would interface with the MSE network and at the theater level with the TRI-TAC network.

The skip echelon scenario is applicable to all theaters of operations. In Europe, skip echelon could be carried out to support combat service support activities that can logically bypass the corps headquarters. In Southwest Asia, the Army component force may be a signal division that receives tactical command and control direction from a joint tactical force (JTF) headquarters but must receive logistics support from a theater army area. In this event, direct coordination would be required between the division and the theater army, and GMF SATCOM would provide the needed long-distance communications into the division MSE network. In Korea, the command and control of divisional forces can be from the commander in chief (CINC) to the division command without intermediate headquarters. This skip echelon scenario between the division MSE system and the CINC headquarters would be supported by GMF SATCOM.

Because skip echelon operations normally require communications beyond that which the MSE LOS equipment can provide, GMF SATCOM is a logical communications means to

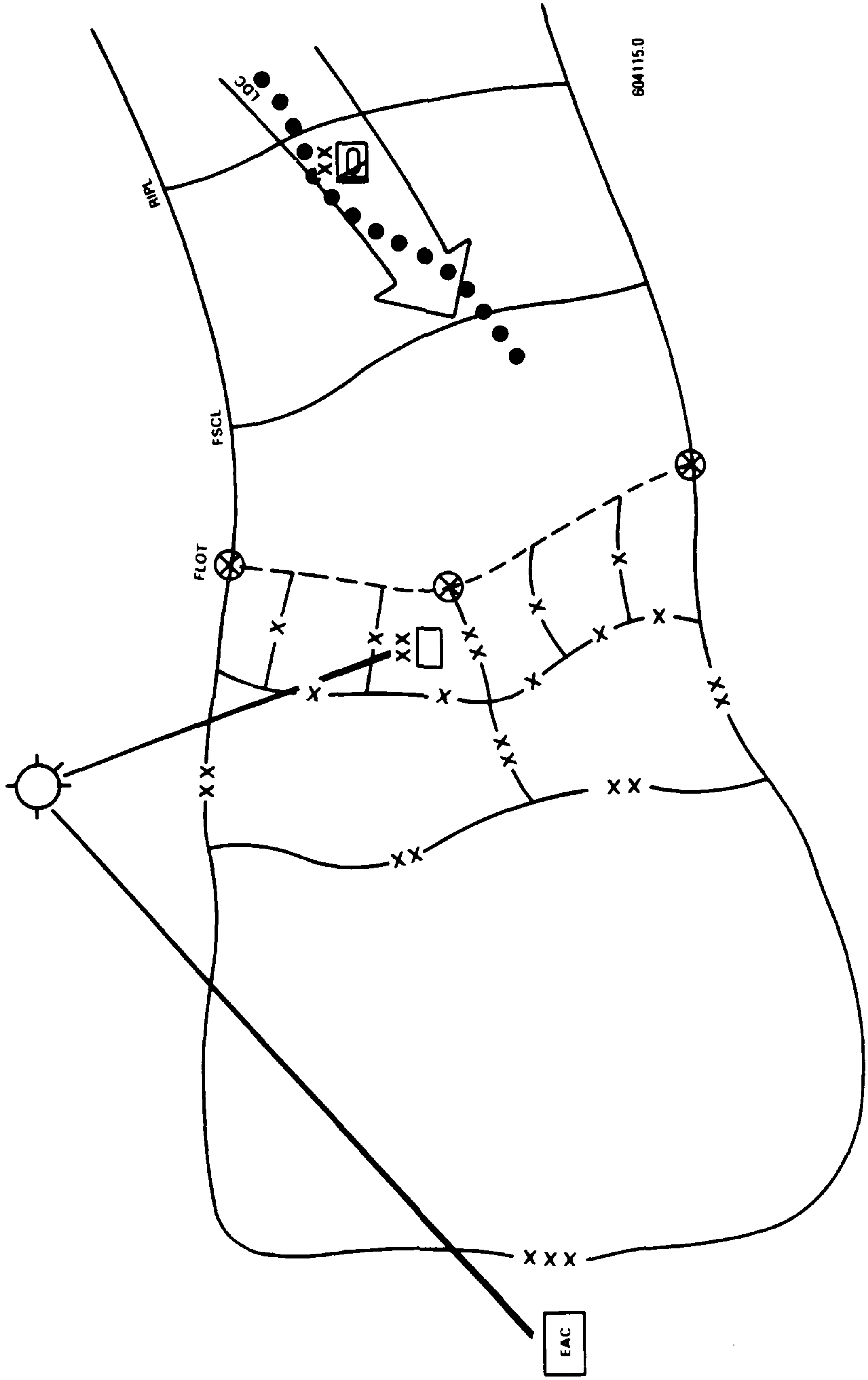

Figure 5-2. Skip Echelon

provide reliable multichannel capability between the units involved in skip echelon operations.

5.1.3 Enclave Connectivity

Another scenario that has been documented concerning the use of GMF SATCOM in conjunction with MSE is termed enclave connectivity. In this scenario, groups of MSE users, usually separated by long distances or restrictive terrains, are interconnected and fully integrated into a coherent MSE network by using GMF SATCOM transmission capabilities. This concept is shown in Figure 5-3. For example, a corps operating with three to five divisions in Southwest Asia will normally have the divisions separated by hundreds of miles. An integrated corps/division MSE system cannot be established because of the distance restrictions on the LOS radios between nodes. AN/TSC-85A/93A terminals would be configured to interconnect the division and corps MSE systems into one that is fully integrated. The number of SATCOM terminals and the network's configuration (e.g., point-to-point, hub and spoke, mesh) would depend on the number of nodes requiring SATCOM connectivity.

Another example of enclave connectivity would be the case of a number of MSE users (and nodes) within a division or corps network being isolated by a terrain obstacle, for example, mountains. AN/TSC-85A/93A terminals would be used to provide several links between the MSE users and the remainder of the networks. This example applies both to Korea and Europe. It should also be pointed out that the enclave of MSE users could be large (e.g., a division) or small (e.g., three nodes). The mission of the users within the enclave will determine the requirement to provide satellite connectivity to it.

The enclave scenario also includes interconnecting forces deployed outside the normal corps boundaries but requiring connectivity into the system. An example of this situation

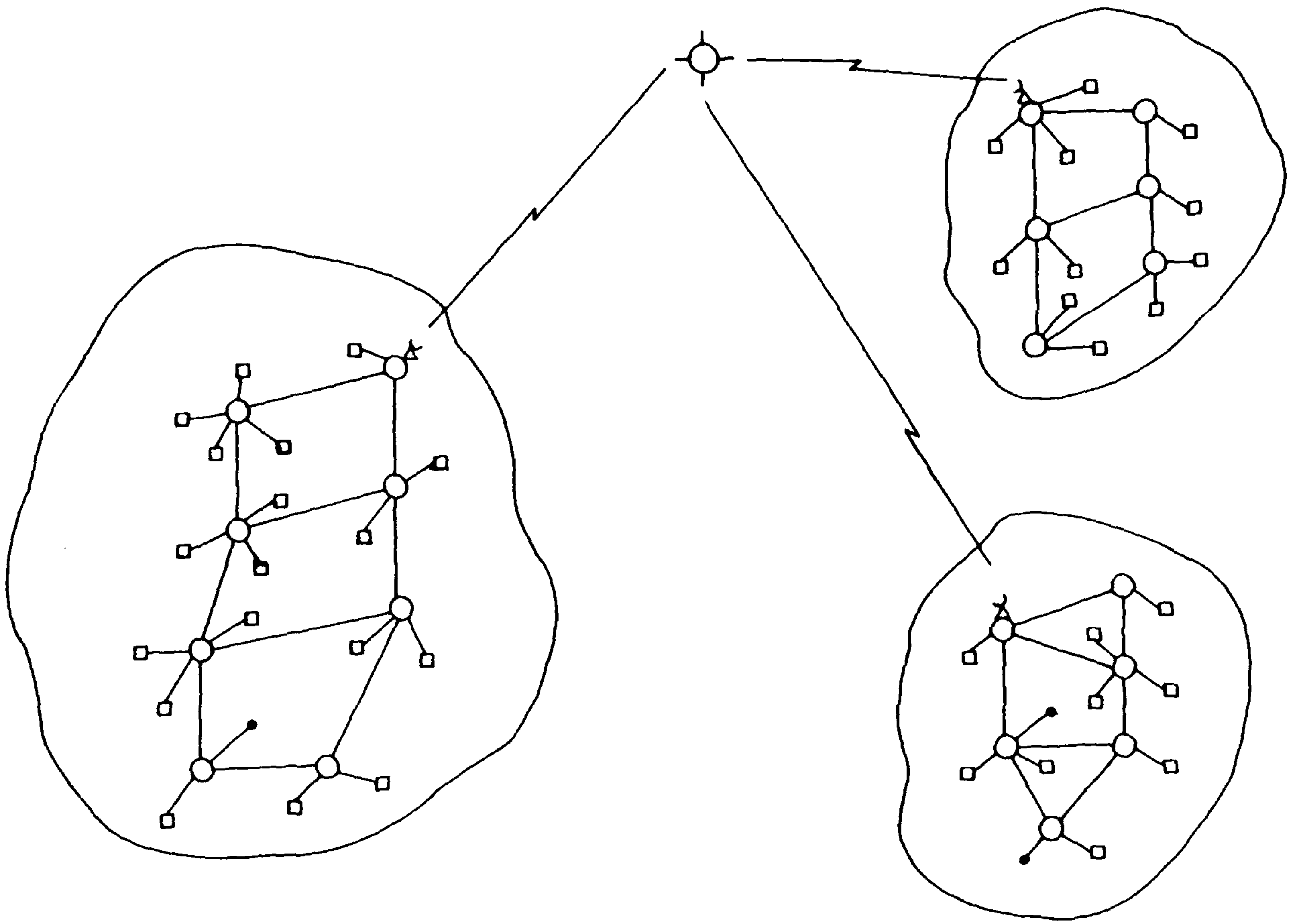

Figure 5-3. Enclave Connectivity

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would be a division in Europe deployed on short notice to a section outside its parent corps. While under the operational control of another corps, the division may still have special reporting or logistics requirements that dictate connectivity with the parent headquarters. GMF SATCOM would be used to provide this connectivity. There will also be requirements to provide communications between corps units; GMF SATCOM could be used to provide this connectivity.

5.2 THEATER DEPLOYMENT

The availability of both the MSE system and the GMF(SHF) terminals in the three theaters of interest is shown in Table 5-1.

Table 5-1. Comparison of MSE and GMF(SHF) SATCOM Fielding Dates

Theater	Fielding Date	
	AN/TSC-85A/-93A	MSE
European Corps		
I	1987	1993
III	1986	1990
V	1986	1990
VII	1986	1992
Southwest Asia		
XVIII Corps	1986	1992
Korea		
2ID	1985	1992-93

From Table 5-1 it is clear that the GMF(SHF) terminals will be in the field and operational 4 to 7 years before the MSE system is deployed. In Europe, GMF(SHF) fielding is on-going, whereas MSE will not be deployed to the corps stationed there until 1990 (V Corps) and 1992 (VII Corps). Initial fielding of MSE will be to the III Corps, deployed in CONUS, but earmarked for Europe. MSE fielding for this unit will take

place in 1990. For Southwest Asia, there is a 6-year difference in fielding dates between MSE and the AN/TSC-85A/93As. For Korea, the difference is 7 years. The overall conclusion is that the AN/TSC-85A/93As will be in use at the division, corps, and EAC levels and many operational lessons will have been learned about their use before MSE fielding. This will, no doubt, have an effect on the actual employment of the satellite communications capability with MSE.

Another factor affecting the employment will be the scheduled enhancements to the AN/TSC-85A and AN/TSC-93A terminals (i.e., the antijam/control modem (AJ/CM), the low-rate multiplexer (LRM), and the universal modem). None of these enhancements are presently planned for application with MSE, since the user bit rates accommodated by the enhancements are lower than specified for MSE trunk groups and for the most part could support only individual MSE channels rather than an entire trunk group. Nevertheless, the study team assumes that the AirLand battle doctrine will be valid in the timeframe 1989 through 1993 when MSE and GMF(SHF) SATCOM will be in the field together. The remaining sections discuss utilization of GMF(SHF) SATCOM with MSE in each theater.

5.2.1 Europe

In this section it is assumed that MSE and GMF(SHF) SATCOM systems are available as shown in Table 5-2.

Table 5-2 indicates that six AN/TSC-85A/93A terminals are available to each corps in Europe. These terminals are to be pooled and used to support missions as directed by the corps commander. The MSE systems listed in Table 5-2 represent the allocation of MSE sets of equipment (e.g., NCSs, LENs, SENs, etc.) described in Chapter 4. Both the corps signal brigade and the division signal battalions will have MSE equipment to support the corps.

Table 5-2. Allocations of GMF(SHF) SATCOM and MSE in European Corps

Corps	SHF SATCOM TSC-85	SHF SATCOM TSC-93	MSE Systems* Corps	MSE Systems* Division
I	2	4	1	3
V	2	4	1	3
VII	2	4	1	4
III	2	4	1	5

*An MSE system for corps/division consists of equipment quantities as defined in Table 4-4.

Table 5-2 indicates a 15-division force in the theater during hostilities. Currently, only V and VII Corps are in theater. With the force allocation as presented in Table 5-2, a number of the documented scenarios are applicable.

The use of the AN/TSC-85A/93A terminals in a deep battle scenario will be planned for by each of the four corps. Such planning would consider the specific mission to be accomplished and establish the size of the forces to undertake it. A division or a reinforced brigade is a likely deep attack force. Depending on the depth of such an attack beyond the FLOT, GMF(SHF) SATCOM would be considered to support the mission and provide entry into the corps/division network behind the FLOT. Given the critical nature and depth (e.g., 400 km) of a deep battle mission, the study team concluded that the AN/TSC-85A/93A assets at corps level would be used to provide a critical command and control (C^2) link between the unit carrying out the mission and the controlling headquarters (e.g., corps or division). Combat net radios without airborne

or ground relay could not provide the required connectivities more than 60 km beyond the FLOT.

The study team also concluded that the Army would plan to use the GMF terminals for skip echelon operations. This could be in conjunction with a deep battle mission in which a brigade-sized force would report directly to a controlling corps headquarters. However, the use of the 85A/93As at critical nodes (e.g., division support command) is possible to provide direct trunks into the EAC (theater/theater army) area common user (e.g., TRI-TAC system) for logistics support activities.

5.2.2 Southwest Asia

The GMF(SHF) SATCOM allocations to units destined for Southwest Asia are significantly higher at the corps and division levels than those for the Army forces in Europe. The Southwest Asian allocations of GMF(SHF) SATCOM and MSE systems are shown in Table 5-3.

Table 5-3. Allocation of GMF(SHF) SATCOM and MSE in Southwest Asia

Corps	SHF SATCOM		MSE System	
	TSC-85A	TSC-93A	Corps	Division
XVIII	5	8	1	-
7, 24, 82, 101 Divisions	8	12	-	4

The XVIII Corps has three more TSC-85As and four more TSC-93As than a similar corps in Europe. The MSE allocation at corps and division is comparable to that of a four-division European corps. Based on these allocations and a review of

Army deployments for Southwest Asia (Reference 1), the study team concluded that the Army plans to use GMF(SHF) SATCOM to support deep battle, skip echelon, and MSE enclave-to-enclave scenarios.

Carrying out any of these scenarios will depend on the area of operations, the level of hostilities, and the size of the corps force employed in Southwest Asia. Deep battle scenarios, with GMF SATCOM connecting the deep battle unit with the corps MSE network, can be envisioned in desert operations over very large distances. Skip echelon use of the GMF(SHF) SATCOM appears to be a high priority and very likely scenarios for implementation at the division and corps levels. Divisions may be employed on special missions under joint task force control and the GMF(SHF) SATCOM would provide connectivity between the division MSE community and the EAC community. In another example of skip echelon, the GMF(SHF) SATCOM would provide connectivity from MSE users in the corps/division network directly into the Defense Communications System (DCS) (CONUS). The scenario most likely to require the support of GMF(SHF) SATCOM is the "enclave-to-enclave" connectivity. In this scenario, XVIII Corps will have one or more subordinate divisions dispersed over very large distances (e.g., 500 miles). Divisions, in turn, will have brigades separated at distances beyond the capability of the MSE LOS radios. Thus, TSC-85A/93A will be required to provide the connectivity between these enclaves of MSE users. The details of this scenario will be developed and evaluated in the next phase of this study.

A final point is that the number of GMF(SHF) SATCOM terminals will be sufficient to allow several of these missions to be supported simultaneously.

5.2.3 Korea

The Korean theater presents unique challenges for the employment of both MSE and GMF(SHF) SATCOM. The system scheduled for employment there is shown in Table 5-4.

Table 5-4. Allocation of GMF(SHF) SATCOM and MSE in Korea

Unit	SHF SATCOM TSC-85A	SHF SATCOM TSC-93A	MSE System
2nd Division	2	3	1 Division

Only one division set of MSE is scheduled to be fielded in Korea. Since the Army has stated that operations will require an integrated corps/division MSE network, it is not clear how the division stand-alone MSE system will function to support the Second Division. Although not explicitly stated in available Army documents, utilization of GMF(SHF) SATCOM as an overlay to the MSE system seems to be the most likely scenario for Korea. The study team determined that nodal trunking would require use of SHF SATCOM due to the particularly mountainous terrain creating obstacles to the MSE LOS radios. Another potential and likely scenario using GMF(SHF) SATCOM with MSE would be skip echelon. In this scenario, the division's MSE network would be connected to EAC activities using trunking provided by the TSC-85As. The study team determined that neither deep battle nor MSE enclave-to-enclave connectivity were very likely scenarios for Korea. This determination was based on the fact that the primary mission of the division in Korea would be active defense, at or near the FLOT, and that no forces would be available to conduct a large-scale maneuver deep inside North Korean territory. The enclave-to-enclave scenario was rated as low probability by the study team because

of the short distances separating division, brigade, and battalion units in the defensive zone of operations.

5.3 NETWORK CONTROL

Based on the overall Army C^3 architecture and the description of both GMF(SHF) SATCOM and MSE control mechanisms provided previously, it is clear that control coordination among the various systems is required.

Table 5-5 lists the hierarchy of control mechanisms that are planned for the MSE, the GMF SATCOM systems, and the TRI-TAC systems.

Table 5-5. Network Control Elements

System/Network	Control Element	Echelon of Employment
MSE	SCC	Corps (Master, Standby)
	SCC	Division (Slave, Stand-Alone)
TRI-TAC	CSPE	Theater
	CSCE	Echelons Above Corps
	CNCE	Echelons Above Corps
GMF SATCOM	AN/TSC-85	Limit Control at Division Corps, Theater
	MSQ-114	Theater (Mobile)
	FSQ-114	Regional Fixed)

In a theater environment, the control elements would be deployed as shown in Figure 5-4. It is clear from this figure that control of the network of networks is mandatory to ensure flexibliity, survivability, and performance of Army theater and

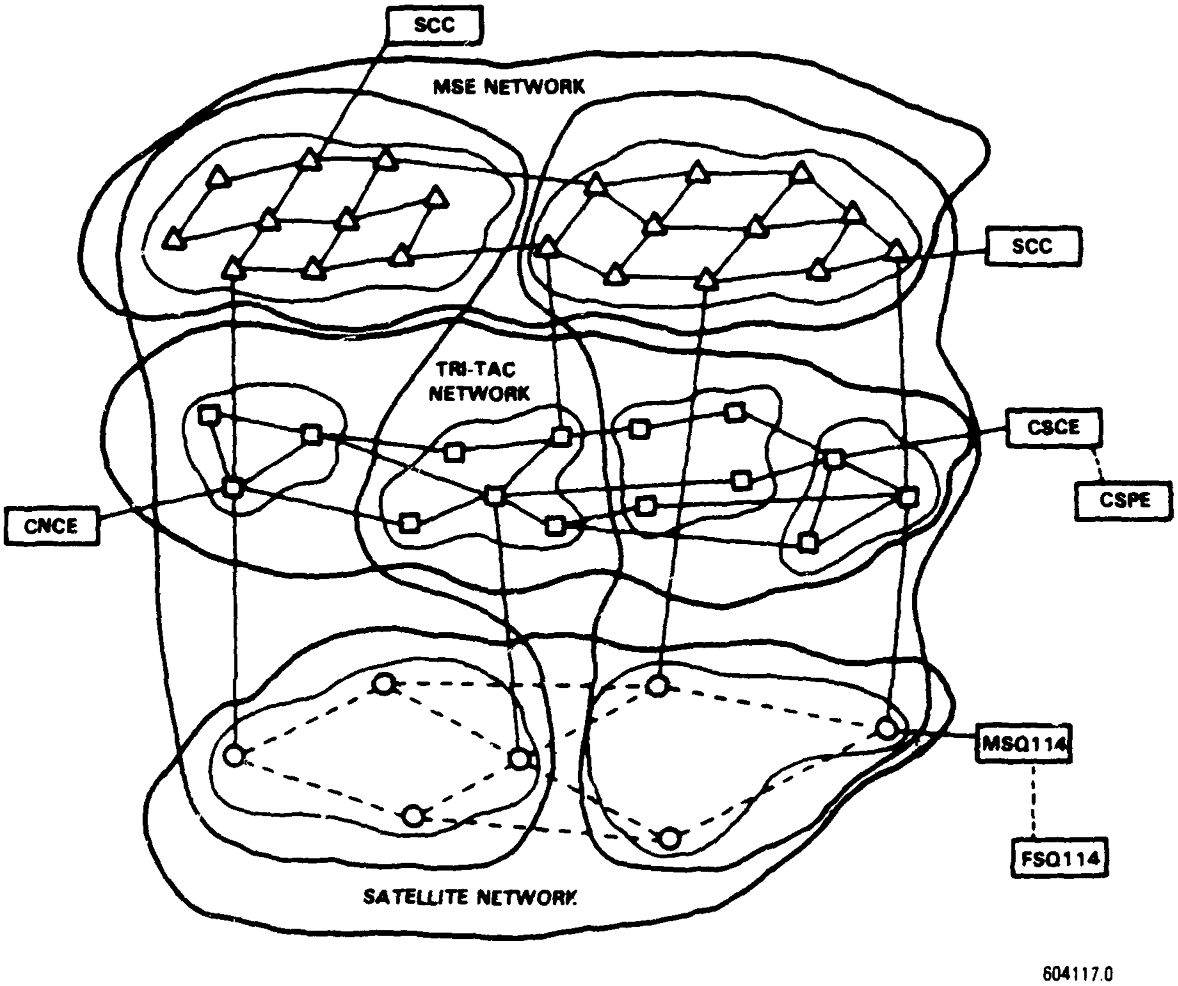

Figure 5-4. Theater Control Requirements

tactical communications. Several points can be made about control. As a minimum, the MSE control at the corps level (that is, the level at which the entire Corps network will be managed) requires an interface to the "external" TRI-TAC EAC planning element, the communications system planning element (CSPE), and the communications nodal control element (CNCE) if one is deployed in conjunction with the AN/TTC-39 switches. The primary requirement for this control interface is to ensure access into and out of the MSE network. For example, MSE subscribers at corps level may require theater and CONUS DCS access. Planning for this access requires the planners in the corps SCC to work with the CSPE. Additionally, both the MSE control element and the TRI-TAC EAC planners must coordinate with the GMF subnet controller to establish AN/TSC-85A/93A links with their assigned assets. Planning guidance and technical direction, along with link authorizations and real-time control of the satellite links, will emanate from GMF controller. In theaters where both division and corps units are assigned both MSE and AN/TSC-85A/93A, the control interfaces and coordinating activities are critical. Specific operational and technical procedures and interface requirements for MSE-GMF SATCOM control must be developed.

5.4 ANALYSIS

As noted previously, the documented use of GMF SATCOM in MSE is limited and basically consists of using MILSATCOM only when terrestrial LOS cannot meet mission requirements because of distance or terrain constraints. The two areas where this is envisioned use GMF SATCOM as multichannel interswitch trunks between MSE nodal switching elements or between an MSE node and a TRI-TAC node at EAC.

While no studies have yet quantified the performance impact of MILSATCOM use in support of MSE, the following

observations do indicate that additional work is required to more fully evaluate the potential of MILSATCOM to support MSE.

1. According to the MSE system specification (Reference 3), GMF(SHF) SATCOM systems can be used in place of any multichannel LOS radio system within the MSE network. Thus, the connection types shown in Table 5-6 are possible using either a hub-spoke or a mesh configuration of GMF terminals.

Table 5-6. MSE Connection Types

Connection	No. of Channels	Data Rate (kbps)
NCS to NCS	64	1024
NCS to LEN	32	512
NCS to SEN	16	256
NCS to RAU	9	256
NCS to EAC	8	256

While five different types of connections have been specified, only two--NCS to NCS and NCS to EAC--are discussed in documented scenarios.

Note that the interface between GMF(SHF) SATCOM and MSE is specified at trunk group rates from 1024 kbps to 256 kbps using multiplexing equipment internal to MSE. This interface precludes the use of the LRM and AJ/CM enhancements to GMF(SHF) SATCOM. The next phase of this study will address the MSE performance impact of providing smaller trunk groups (3 to 5 channels) via individual channel interfaces with MSE that could then be multiplexed via the LRM.

It should also be noted that no single-channel satellite interfaces such as could be provided via the AJ/CM or Milstar terminals have yet been projected for MSE. These will also be considered in the next phase of the study.

The use of MSE internal multiplexing at 16 kbps per channel rather than the standard Army tactical (ATAC) multiplexer (which uses 48 kbps per channel) associated with TSC-85As and -93As provides an almost 300 percent increase in the number of traffic channels that can be provided by DSCS/GMF.

2. The normal trunk group requirement for an NCS-to-NCS link is 64 16-kbps channels or 1024 kbps. This is approximately twice the rate planned by the Army for GMF(SHF) SATCOM employment. Further study is required to determine what the performance impact would be in using trunk groups of less than 64 channels between node centrals. This impact will be addressed in the next phase of this study.

3. Two limiting factors must be considered in employing GMF(SHF) SATCOM in support of MSE. The first is the number of ground terminals available to establish MSE links. The second is the capacity of the satellite itself to support MSE traffic as well as other channel 2 traffic in the theater.

The number and type of ground terminals dictate the maximum number of links that can be supported. Since a complete satellite link requires two earth terminals, one AN/TSC-93A can support half of a single link between MSE nodes, and an AN/TSC-85A can support half of four links. Thus, to calculate the maximum number of links that can be

supported by the ground terminals, the following formula applies:

$$\frac{(4 * \text{No. of AN/TSC-85A}) + (\text{No. of AN/TSC-93A})}{2}$$

Table 5-7 shows the results of applying this formula to the GMF(SHF) SATCOM terminals by theater and by echelon.

To compare these link quantities with those required by MSE, Table 5-8 develops the MSE link requirements by theater. The table assumes the baseline MSE configuration, which has each NCS connected to four other NCSs and each SEN connected to a single NCS. No attempt was made to differentiate the required capacities of each link; only the total number of links was determined.

Table 5-9 provides the comparison by theater of the relative number of MILSATCOM links available compared to the total number of links required by MSE. Obviously, the potential for GMF SATCOM to provide a significant portion of the MSE links is much greater in Korea than in Europe.

The second factor, satellite capacity available for MSE, is much more difficult to determine, but using the results of the analysis from Reference 1 as shown in Table 3-2 as typical capacities, it was shown that the following number of 16-kbps channels could be supported in the theater indicated:

Europe	2070
SWA	720
Korea	1605

These numbers are for all users of the channel 2 transponder, not just for MSE use.

Table 5-7. MSE Component Allocations and Link Capacity by Theater

THEATER	FORCE SIZE	MSE COMPONENTS			NO.OF LINKS			TOTAL LINKS
		NCS	LEN	SEN	NC-NC 64 CHAIN	NC-LEN 32 CHAIN	NC-SEN 10-13 CHAIN	
KOREA	1 DIVISION	4	1	16	6	2	16	24
SWA	1 CORPS W/4 DIV	44	7	182	88	14	182	284
EUROPE	1 CORPS W/3 DIV	39	6	166	78	12	166	256
	1 CORPS W/5 DIV	56	8	224	112	16	224	352
	4 CORPS W/5 DIV	280	40	1120	560	80	1120	1760

604120.0

Table 5-8. SHF SATCOM Allocations and Link Capacity by Theater

THEATER	ECHELON	TERMINAL TYPE TSC-85A	TERMINAL TYPE TSC-93A	TOTAL NO OF LINKS
EUROPE	EAC	7	11	19
	CORPS	8	16	24
SWA	EAC	9	16	26
	CORPS	5	8	14
	DIVISION	8	12	22
KOREA	EAC	8	8	20
	DIVISION	2	3	4*

*TOTAL LINKS ARE LIMITED BY THE NUMBER OF TERMINALS ALLOCATED TO THE DIVISON

604121.0

Table 5-9. SATCOM vs MSE Link Capacities

	EUROPE	SWA	KOREA
TOTAL NUMBER OF MSE LINKS REQUIRED	1620	262	24
TOTAL NUMBER OF GMF LINKS POSSIBLE	24	36	4
% GMF LINKS OF MSE LINK REQUIREMENT	1.5%	13.7%	17%

604122.0

The potential problem is that even if all DSCS channel 2 capacity were allocated to MSE in, for example, Southwest Asia, the 720 channels divided among the 22 possible satellite links yields 32 channels per link or barely enough capacity to provide half of the specified NCS-to-NCS link requirement of 64 channels.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

The fundamental conclusion to be drawn from the study to date is that while Army Ground Mobile Forces (GMF) super high frequency (SHF) satellite communications (SATCOM) can--and in some cases must--be used in support of MSE, the present planned use does not fully exploit the potential of MILSATCOM to meet the needs of the Army tactical forces. Concepts of operations for employing MILSATCOM must be developed based on a detailed analysis of each potential link requirement in context with the total transmission capability of all transmission means. The following factors must be evaluated to determine what transmission means should be employed:

- Criticality of the link to C^2 or mission support
- Availability of other means of transmission
- Range (distance to be covered)
- Siting restrictions
- Systems reconfigurability
- Link survivability requirements
- Link performance (capacity, grade of service, etc.)
- Demands on the space segment (power, bandwidth).

To evaluate the potential benefits of MILSATCOM augmentation to MSE, it is first necessary to consider the general case of MILSATCOM supporting a tactical switched network without the restrictions imposed by the presently designed GMF and MSE systems. These restrictions include such parameters as satellite capacity and MSE interface design. With this view in mind, the potential uses of MILSATCOM in support of MSE can be placed into four general architectural categories:

1. As parallel links to augment terrestrial links
2. As the only links to connect separate enclaves of MSE

3. As gateway links to networks outside MSE
4. As remote subscriber access lines to an MSE network.

These four categories, depicted in Figure 6-1 and discussed in more detail below, encompass those uses described in Chapter 5 but also include additional potential uses.

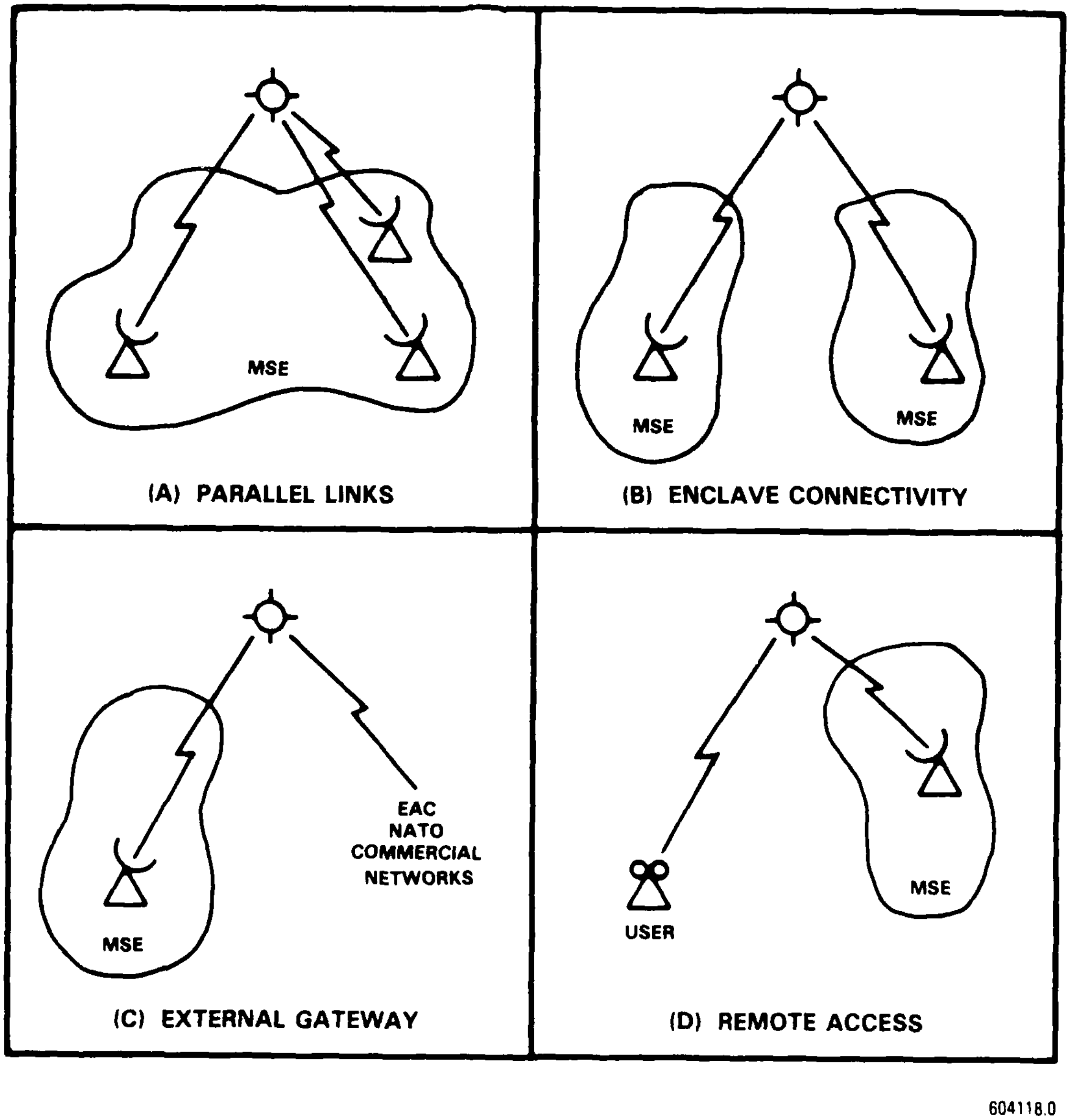

Figure 6-1. Architectural Categories of MILSATCOM MSE Support

6.1 USE OF MILSATCOM IN PARALLEL WITH TERRESTRIAL LINKS

While not presently projected in any of the Chapter 5 scenarios, it is possible to mix terrestrial and satellite links in a network using a flood search routing algorithm as shown in Figure 6-2. Search messages would be transmitted over both the terrestrial links and the satellite link. However, due to the long transmission delay involved with satellites, the search message transmitted over the satellite would arrive at the destination switch after all search messages transmitted over terrestrial links even if a number of intermediate switch nodes were involved in retransmitting the search message. As a result, the satellite circuits would only be chosen when all terrestrial paths were full or otherwise unavailable (destroyed). Thus, the satellite links effectively become overflow trunks.

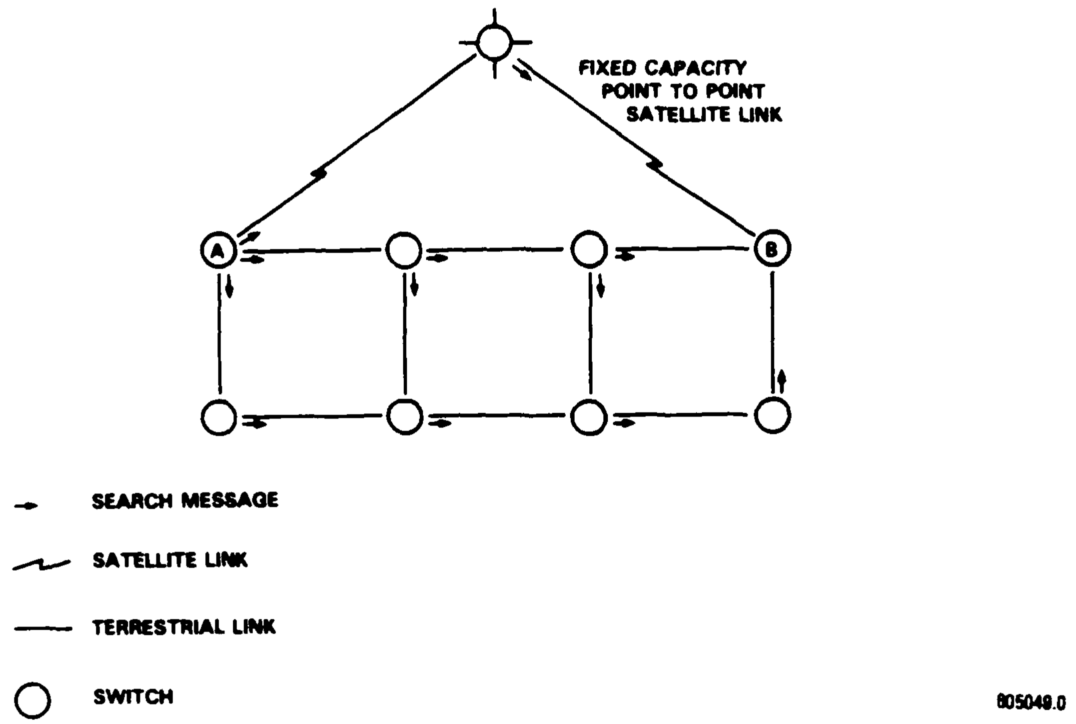

Figure 6-2. Parallel Links With Fixed Capacity

When the satellite link used for this overflow purpose is a fixed-capacity point-to-point link and where satellite capacity is an extremely limited resource this use is not very efficient. However, if the satellite capacity were dynamically assignable among a number of satellite terminals arranged in a mesh configuration as shown in Figure 6-3, the added satellite capacity could significantly improve the overall network grade of service while at the same time making maximum use of the satellite capacity. This is particularly true if the network traffic patterns change dynamically, or if the major sections of the terrestrial network are destroyed.

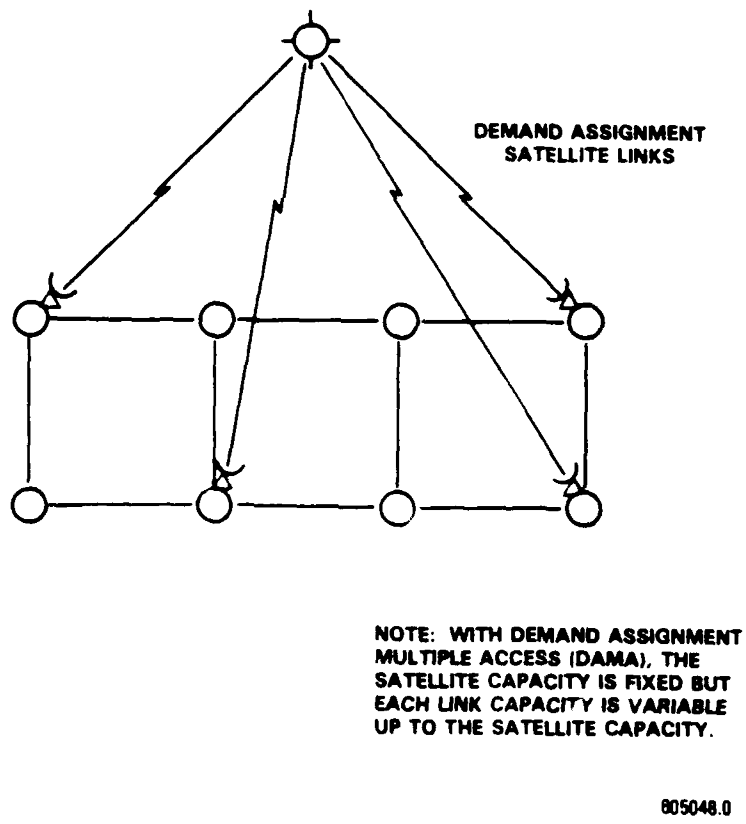

Figure 6-3. Parallel Links With Demand Assignment

Another possibility is to use satellite links on calls that would otherwise require too many terrestrial links. This approach would require that the link count be carried along with the search message. Each switch repeating the search message would increase the count by one. When the count reached "n" links, the search would be stopped except on the switch receiving the message via satellite, which instead resets the count to one. This way users within "n" links would be reached by terrestrial circuits and those further away by satellite circuits (see Figure 6-4).

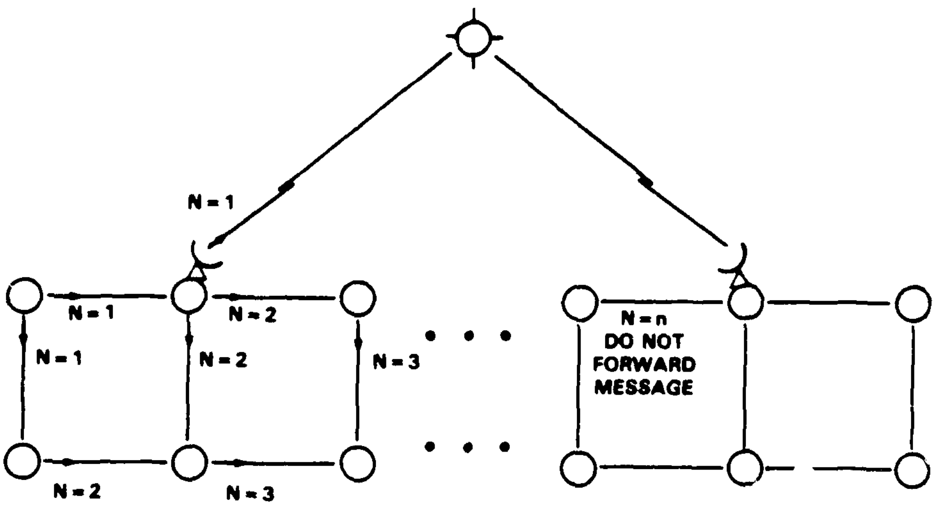

Figure 6-4. Satellite Link Used for Distant Calls

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SATELLITE USE IN S..(U) M/A-COM GOVERNMENT SYSTEMS DIV
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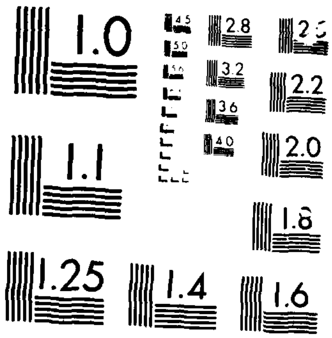
1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.8
3.2
3.6
4.0

6.2 USE OF MILSATCOM TO CONNECT MSE ENCLAVES

As indicated in Chapter 5, it may be necessary to use MILSATCOM to connect MSE regional networks (MSE enclaves) because of either distance or terrain constraints that preclude using terrestrial links. This would be accomplished through satellite links located at selected node central switch (NCS) locations that would act as gateways to the various enclaves. In this case it would be desirable for the gateway switch to determine if a search message should be transmitted over a given gateway trunk or not. This would preclude forwarding unnecessary search messages and risking possible congestion in the network. This could be accomplished by employing area codes in the numbering plan. In this way, the gateway would act as an artificial grid boundary protecting the other enclaves from all search mesages except the ones specifically directed to it. Valid forward search messages would propagate across gateway trunks as if the two enclaves formed a single grid. As in the previous case, point-to-point fixed-capacity satellite links could be used to connect the enclaves. In the limiting case where there are only two enclaves or in the deep battle scenario, this is a viable approach. However, in the case of three or more enclaves, the most effective use of MILSATCOM would take advantage of the satellite's ability to act as a broadcast repeater with every ground station receiving the search messages transmitted by every other ground station. In this case each gateway switch would transmit to all other gateway switches on one satellite channel and would monitor the channels of all other gateway switches, looking for calls destined for its region. The assignment of traffic channels in this case would be handled using a demand- assignment technique that would use the limited satellite bandwidth more efficiently than fixed-assigned channels between enclaves.

6.3 USE OF MILSATCOM AS GATEWAY LINKS TO NETWORKS OUTSIDE MSE

The employment concepts for MSE discussed in Chapter 4 provide for the interface of MSE to external networks. These external networks include TRI-TAC networks (used at echelons above corps (EAC) or by other Services, e.g., Air Force), commercial networks, and NATO networks. Present scenarios employ MILSATCOM only in multichannel digital trunk groups between MSE and TRI-TAC at EAC. Under the right circumstances, it is possible that MILSATCOM could be used to provide single-channel analog interfaces between MSE and commercial or NATO networks.

6.4 USE OF MILSATCOM FOR REMOTE ACCESS TO MSE

As indicated in Chapter 4, mobile subscribers to MSE via mobile secure radio terminals (MSRTs) are limited to a range of 15 km from a radio access unit (RAU). Providing a single-channel MILSATCOM interface to MSE similar to that provided to the combat net radio could extend that range to anywhere within the satellite footprint. Thus, a user could have access to all subscribers on the MSE network as well as to other networks to which the MSE network had an established interface.

This same capability could be provided to a group of mobile users by locating an RAU and ground terminal within their area of operations and providing a satellite link between the RAU and an MSE NCS. This particular application is similar to the deep battle scenario of Chapter 5; however, the size of the force as well as the amount of equipment required is considerably less.

6.5 RECOMMENDATIONS

In many cases the concepts set forth above do not lend themselves to an immediate implementation using existing Army GMF(SHF) SATCOM assets. For example, no demand-assignment multiple-access (DAMA) capability is presently projected for GMF(SHF) SATCOM users and no single-channel MILSATCOM interfaces to MSE are projected. However, GMF(SHF) SATCOM upgrades and programs such as Milstar as well as enhancements to the existing system should be more fully evaluated to determine the performance benefits that could accrue to MSE with their use.

In subtasks 2 and 3 of the current effort, detailed scenarios for the use of MSE will be developed and the concepts discussed above integrated into them. The feasibility and performance of the resulting configurations will be analyzed. The study team will also investigate techniques for modeling the various scenarios using an event-by-event simulation tool developed by PRC for use in evaluating network performance of MSE.

GLOSSARY

ACU	Area common user
ADA	air defense artillery
AJ/CM	antijam control modem
ATL1,2	Atlantic 1, Atlantic 2
C^3	command, control, and communications
CDMA	code-division multiple access
CINC	commander in chief
CNCE	communications nodal control element
CNR	combat net radio
COMSEC	communications security
CSPE	communications system planning element
CSS	combat services support
DCA	Defense Communications Agency
DCS	Defense Communications System
DDS	data distribution system
DGM	digital group multiplexer
DIBITS	digital inband trunk signaling
DNPS	DSCS Network Planning System
DNVT	digital nonsecure voice terminal
DoD	Department of Defense
DSCS	Defense Satellite Communications System
DTG	digital transmission group
DTH	down the hill
EAC	echelons above corps
EHF	extra high frequency
EIRP	effective isotropic radiated power
EP	Eastern Pacific
FDMA	frame-division multiple access
FLOT	forward line of own troops
GDA	gimballed dish antenna
GMF	Ground Mobile Forces
GMFOC	GMF Operational Center
HPA	high-power amplifier
IEW	intelligence and electronic warfare
IO	Indian Ocean
JTIDS	joint tactical information distribution system
LEN	large extension node
LGM	loop group multiplexer
LOS	line of sight
LRM	low-rate multiplexer

MBR	multiple beam receiver
MILSATCOM	Military Satellite Communications
MSE	mobile subscriber equipment
MSRT	mobile secure radio terminal
MVR	maneuver control
NCS	node central switch
NCT	network control terminal
NRZ	nonreturn to zero
O&O	operational and organizational
RAU	radio access unit
RITA	Reseau Integre de Transmission Automatique
RMC	remote multiplexer combiner
SATCOM	satellite communications
SCC	system control center
SCOTT	Single Channel Objective Tactical Terminal
SEN	small extension node
SEP	signal entry panel
SHF	super high frequency
SINCGARS	single-channel ground and airborne radio system
TACSAT	tactical satellite
TED	trunk encryption device
TGC	trunk group cluster
TRI-TAC	joint tactical communications
TSSP	tactical satellite signal processor
WHCA	White House Communications Agency
WP	Western Pacific

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(U) This report, after describing both the Army Ground Mobile Forces (GMF) super high frequency (SHF) satellite communications (SATCOM) system and the mobile subscriber equipment (MSE) system, documents the relationship between the two systems. It summarizes current Army plans to use GMF(SHF) SATCOM in support of MSE and analyzes the impact of that planned utilization. The report establishes the baseline for further study to develop MILSATCOM augmentations/enhancements to better support MSE.

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